Question1

A photosensitive surface has work function ϕ. If photon of energy 3ϕ falls on this surface, the electron comes out with maximum velocity of 4×10^6 m/s When photon energy is increased to 7ϕ then maximum velocity of photoelectron will be

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Options:

A.

$4\sqrt{3} \times 10^6$ m/s

B.

$2\sqrt{3} \times 10^6$ m/s

C.

$4\sqrt{3} \times 10^3$ m/s

D.

$2\sqrt{3} \times 10^3$ m/s

Answer: A

Solution:

For photoelectric effect,

$$K \cdot E_{\max} = E - \phi \qquad \ldots (i)$$

Given: $E_1 = 3\phi$ and $E_2 = 7\phi$

From (i),

$$K \cdot E_1 = 3\phi - \phi = 2\phi$$
$$K \cdot E_2 = 7\phi - \phi = 6\phi$$
$$But, K \cdot E_1 = \frac{1}{2}mv_1^2 \text{ and } K \cdot E_2 = \frac{1}{2}mv_2^2$$
$$\therefore \quad \frac{K \cdot E_1}{K \cdot E_2} = \frac{v_1^2}{v_2^2} = \frac{1}{3}$$
$$\therefore \quad v_2 = \sqrt{3}v_1$$
$$v_2 = 4\sqrt{3} \times 10^6 \text{ m/s}$$

Question2

Energy of the incident photons on the metal surface is initially 4 W and then 6 W where W is the work function of that metal. The ratio of velocities of emitted photoelectrons is

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Options:

A.

$\sqrt{3} : \sqrt{5}$

B.

1 : 2

C.

2 : 3

D.

$\sqrt{2} : \sqrt{3}$

Answer: A

Solution:

Step 1: Recall photoelectric equation

$$K_{\text{max}} = E_{\text{photon}} - W$$

and

$K_{\max} = \frac{1}{2}mv^2$

So,

$v \propto \sqrt{E_{\text{photon}} - W}$

Step 2: Photon energies

- Case 1: $E_1 = 4W \rightarrow$

$K_1 = 4W - W = 3W$

- Case 2: $E_2 = 6W \rightarrow$

$K_2 = 6W - W = 5W$

Step 3: Velocities

$v_1 \propto \sqrt{3W}, \quad v_2 \propto \sqrt{5W}$

So the ratio is

$v_1 : v_2 = \sqrt{3W} : \sqrt{5W} = \sqrt{3} : \sqrt{5}.$

✅ **Final Answer:**

Option A: $\sqrt{3} : \sqrt{5}$

Question3

Let E_c and E_p represents kinetic energy of electron and photon respectively. If de-Broglie wavelength of a photon is twice the de-Broglie wavelength of an electron then E_p/E_c is (speed of electron = C/100 where C is the velocity of light)

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Options:

A.

10

B.

10^2

C.

10^3

D.

10^4

Answer: B

Solution:

Step 1: Write the energy of the photon

The energy of a photon is given by: $E_p = h\nu = \frac{hc}{\lambda_p}$

We know from the question that the photon's de-Broglie wavelength (λ_p) is twice the electron's de-Broglie wavelength (λ_e): $\lambda_p = 2\lambda_e$

So, we substitute λ_p into the energy formula: $E_p = \frac{hc}{2\lambda_e}$

Step 2: Write the kinetic energy of the electron

The kinetic energy of the electron is: $E_c = \frac{p^2}{2m}$ where p is momentum and m is the mass of the electron.

The momentum p can also be written as: $p = \frac{h}{\lambda_e}$

Substitute this into the kinetic energy equation: $E_c = \frac{1}{2m}\left(\frac{h}{\lambda_e}\right)^2 = \frac{h^2}{2m\lambda_e^2}$

Step 3: Find the ratio $\frac{E_p}{E_c}$

Now substitute the formulas from Step 1 and Step 2:

$\frac{E_p}{E_c} = \frac{\frac{hc}{2\lambda_e}}{\frac{h^2}{2m\lambda_e^2}}$

The denominators are complex, but if we multiply by the reciprocal, it looks like this:

$\frac{E_p}{E_c} = \frac{hc}{2\lambda_e} \times \frac{2m\lambda_e^2}{h^2}$

Simplify the terms:

$\frac{E_p}{E_c} = \frac{mc\lambda_e}{h}$

Step 4: Replace λ_e using speed of electron

The de-Broglie wavelength of electron is: $\lambda_e = \frac{h}{p}$ where p is the electron's momentum.

Since the electron's speed $v = \frac{c}{100}$, then $p = m \times v = m \times \frac{c}{100}$.

So, $\lambda_e = \frac{h}{m \times \frac{c}{100}} = \frac{100h}{mc}$
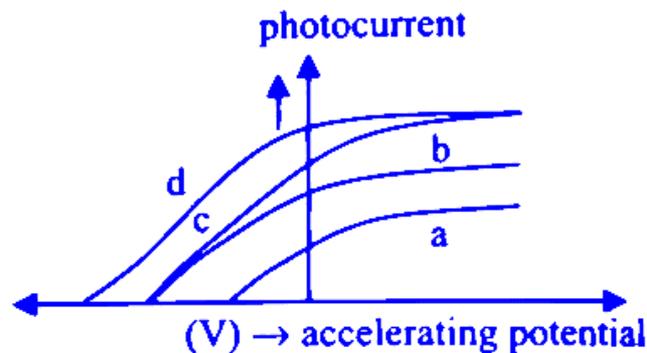
Substitute this back into the ratio:

$$\frac{E_p}{E_c} = \frac{mc}{h} \times \frac{100h}{mc}$$

The m, c, and h cancel out, so:

$$\frac{E_p}{E_c} = 100$$

Question4

The graph shows the variation of photocurrent with anode potential for four different radiations. Let I_a, I_b, I_c and I_d are intensities and f_a, f_b, f_c and f_d be the frequencies for the curves a, b, c and d respectively, then

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Options:

A.

$f_b > f_a, f_b = f_c, I_c = I_d$

B.

$f_b = f_a, f_b > f_c, I_c > I_d$

C.

$f_b < f_a, f_b < f_c, I_c < I_d$

D.

$f_b < f_a, f_b > f_c, I_c = I_d$

Solution:

We know stopping potential is directly proportional to the frequency of the incoming radiation.

$\therefore \quad f_b > f_a, f_b = f_c$

Saturation current for c and d is same, hence intensity

$I_c = I_d$

Question5

Light of incident frequency 3 times the threshold frequency is incident on a photosensitive material. If the incident frequency is made $\left(\frac{1}{4}\right)^{\text{th}}$ and intensity is tripled then the photoelectric current will

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Options:

A. increase.

B. decrease.

C. be $\left(\frac{1}{3}\right)^{\text{rd}}$

D. be zero.

Solution:

Let v_0 be the threshold frequency,

$\therefore \quad$ Incident frequency $(v) = 3v_0 \quad$ ...(given)

The frequency is made $\left(\frac{1}{4}\right)^{\text{th}}$,

$\therefore \quad v' = \frac{3v_0}{4} = 0.75v_0$

As $0.75 v_0

As the new frequency is less than threshold frequency, no current will flow.

Question6

The wavelength ' λ ' of a photon and the deBroglie wavelength of an electron have same value. the ratio of kinetic energy of the electron to the energy of a photon is

(m = mass of electron, c = velocity of light, h = Planck's constant)

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Options:

A. $\frac{2\lambda mc}{h}$

B. $\frac{\lambda mc}{h}$

C. $\frac{h}{2\lambda mc}$

D. $\frac{h}{\lambda mc}$

Answer: C

Solution:

A photon and an electron both have the same wavelength :

$\lambda_{photon} = \lambda_{wavelength} = \lambda$

Photon Energy : $E_{photon} = \frac{hc}{\lambda}$

Electron's de-Broglie wavelength,

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK.E.}} \Rightarrow K.E. = \frac{h^2}{2m\lambda^2}$

Ratio of electron $K \cdot E$ to photon energy,

$$\frac{K.E.}{E_{photon}} = \frac{\frac{h^2}{2\,m\lambda^2}}{\frac{hc}{\lambda}} = \frac{h}{2\,m\lambda} \cdot \frac{1}{c}$$

$$\therefore \frac{K.E.}{E_{photon}} = \frac{h}{2\lambda mc}$$

Question7

If the frequency of incident light in a photoelectric experiment is doubled, then stopping potential will

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Options:

A. be doubled.

B. be halved.

C. become more than double.

D. become less than double.

Answer: C

Solution:

By photoelectric effect,

$eV_0 = hv - \phi$

$\therefore \quad V_0 = \frac{hv - \phi}{e} \ldots (V_0 = \text{initial stopping potential})$

Initial frequency (v) is doubled.

$\therefore V_0' = \frac{h(2v) - \phi_0}{e} \ldots (V_0' = \text{New stopping potential})$

$V_0' = \frac{2hv - \phi_0}{e}$

$V_0' = 2 \cdot \frac{hv - \phi}{e} + \frac{\phi}{e} = 2V_0 + \frac{\phi}{e}$

$\therefore V_0' > 2V_0$

$\therefore$ Stopping potential becomes more than double.

Question8

An electron of mass ' m ' and charge ' e ' initially at rest gets accelerated by a constant electric field ' E '. The rate of change of de-Broglie wavelength of the electron at time ' t ' is

(Ignore relativistic effect)($h = $ Planck's constant)

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Options:

A. $-\dfrac{h}{eEt^2}$

B. $-\dfrac{eEt}{h}$

C. $\dfrac{-mh}{eEt^2}$

D. $-\dfrac{h}{eE}$

Answer: A

Solution:

Force on electron : $F = eE$

Since it's initially at rest, using Newton's 2nd

Law: $a = \dfrac{F}{m} = \dfrac{eE}{m}$

Velocity after time t :

$v = u + at \Rightarrow v = at$

$v = \dfrac{eE}{m}t \quad \ldots\ldots (u = 0)$

By de- Broglie wavelength formula.

$\lambda = \dfrac{h}{p} = \dfrac{h}{mv} \Rightarrow \lambda = \dfrac{h}{m\left(\frac{eE}{m}\cdot t\right)}$

$\therefore \quad \lambda = \dfrac{h}{eEt}$

Now differentiate λ w.r.t. t

$\dfrac{d\lambda}{dt} = \dfrac{d}{dt}\left(\dfrac{h}{eEt}\right) = \dfrac{-h}{eEt^2}$

$\therefore \quad \dfrac{d\lambda}{dt} = -\dfrac{h}{eEt^2}$

Question9

If the electron in hydrogen atom jumps from third Bohr orbit to ground state directly and the difference between energies of the two states is radiated in the form of photons. If the work function of the material is 4.1 eV , then stopping potential is nearly

[Energy of electron in n^{th} orbit $= \frac{-13 \cdot 6}{n^2}$ eV]

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Options:

A. 3 V

B. 4 V

C. 6 V

D. 8 V

Answer: D

Solution:

Finding the energy difference when the electron jumps:

The electron moves from the 3rd orbit ($n = 3$) to the ground state ($n = 1$).

The energy in the nth orbit is $E_n = \frac{-13.6}{n^2}$ eV.

So, $E_1 = \frac{-13.6}{1^2} = -13.6$ eVand $E_3 = \frac{-13.6}{3^2} = \frac{-13.6}{9} = -1.51$ eV.

The energy difference is:$E_{\text{photon}} = E_1 - E_3 = (-13.6) - (-1.51) = -13.6 + 1.51 = -12.09$ eVBut since energy emitted is positive, use 12.09 eV.

Linking energy to the photon:

This energy is carried by the photon that is released: $h\nu = 12.09$ eV

Using the photoelectric equation to find stopping potential:

The photon causes electrons to be emitted from a material that has a work function (ϕ_0) of 4.1 eV.

The equation is: $h\nu = \phi_0 + eV_s$where V_s is the stopping potential.

Plug in the known values:$12.09 = 4.1 + V_s$

Solve for V_s:$V_s = 12.09 - 4.1 = 8.0$ V

So, the stopping potential is about 8 V.

Question10

When a metal surface is illuminated by light of wavelength λ_1 and λ_2, the maximum velocities of photoelectrons ejected are V and 2 V respectively. The work function of the metal is (h = Planck's constant, c = velocity of light, $\lambda_1 > \lambda_2$)

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Options:

A. $\frac{hc}{2\lambda_1\lambda_2}(\lambda_1 - \lambda_2)$

B. $\frac{hc}{\lambda_1\lambda_2}(\lambda_1 - \lambda_2)$

C. $\frac{hc}{\lambda_1\lambda_2}(\lambda_1 + \lambda_2)$

D. $\frac{hc}{3\lambda_1\lambda_2}(4\lambda_2 - \lambda_1)$

Answer: D

Solution:

Given

Two wavelengths λ_1 and λ_2 illuminate a metal surface.

Maximum photoelectron speeds are:

- $v_1 = V$
- $v_2 = 2V$

with $\lambda_1 > \lambda_2$.

Work function ϕ is asked in terms of λ_1, λ_2.

Photoelectric equations

For wavelength λ_1:

$$\frac{1}{2}mV^2 = \frac{hc}{\lambda_1} - \phi \qquad (1)$$

For wavelength λ_2:

$$\frac{1}{2}m(2V)^2 = \frac{hc}{\lambda_2} - \phi \qquad (2)$$

Compute LHS of equation (2):

$$\frac{1}{2}m(4V^2) = 2mV^2$$

Subtract (1) from (2):

$$2mV^2 - \frac{1}{2}mV^2 = \left(\frac{hc}{\lambda_2} - \phi\right) - \left(\frac{hc}{\lambda_1} - \phi\right)$$

$$\frac{3}{2}mV^2 = hc\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right) \qquad (3)$$

Now use eq. (1) to solve for ϕ:

$$\phi = \frac{hc}{\lambda_1} - \frac{1}{2}mV^2 \qquad (4)$$

We need mV^2. From (3):

$$mV^2 = \frac{2hc}{3}\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right)$$

Now plug into (4):

$$\phi = \frac{hc}{\lambda_1} - \frac{1}{2}\cdot\frac{2hc}{3}\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right)$$

$$\phi = \frac{hc}{\lambda_1} - \frac{hc}{3}\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right)$$

Expand:

$$\phi = \frac{hc}{\lambda_1} - \frac{hc}{3\lambda_2} + \frac{hc}{3\lambda_1}$$

Combine the $1/\lambda_1$ terms:

$$\phi = \frac{hc}{3\lambda_2}(-1) + \frac{4hc}{3\lambda_1}$$

$$\phi = \frac{hc}{3\lambda_1\lambda_2}(4\lambda_2 - \lambda_1)$$

Question11

Sodium and copper have work functions 2.3 eV and 4.5 eV respectively. The ratio of threshold wavelength of sodium to that of copper is nearest to

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Options:

A. 1 : 4

B. 4 : 1

C. 1 : 2

D. 2 : 1

Answer: D

Solution:

Work functions:

- Sodium: $\phi_{Na} = 2.3\,\text{eV}$

- Copper: $\phi_{Cu} = 4.5\,\text{eV}$

Threshold wavelength is related to work function via:

$\lambda = \frac{hc}{\phi}$

where ϕ is in energy units (eV), and $hc \approx 1240\,\text{eV·nm}$.

So:

$\lambda_{Na} = \frac{1240}{2.3}\,\text{nm}, \quad \lambda_{Cu} = \frac{1240}{4.5}\,\text{nm}$

Now the ratio:

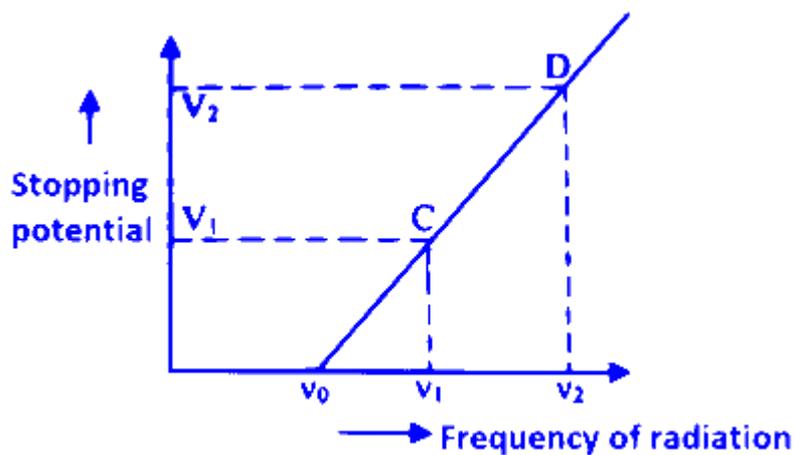$\frac{\lambda_{Na}}{\lambda_{Cu}} = \frac{1240/2.3}{1240/4.5} = \frac{4.5}{2.3}$

$\frac{\lambda_{Na}}{\lambda_{Cu}} \approx 1.96 \approx 2$

So the ratio of threshold wavelengths (Na : Cu) ≈ **2 : 1**

✅ **Answer: Option D (2 : 1)**

Question12

Graph shows variation of stopping potential with frequency of incident radiation on a metal plate. The value of Planck's constant is [e = charge on photoelectron]

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Options:

A. $\frac{e(V_2 - V_1)}{v_1 v_2}$

B. $\frac{e V_1 V_2}{(v_2 - v_1)}$

C. $\frac{e(V_2 - V_1)}{(v_2 - v_1)}$

D. $\frac{e(V_1 V_2)}{v_1 v_2}$

Answer: C

Solution:

$$eV_o = h\nu - \phi$$

From graph

At C,

$$eV_1 = h\nu_1 - \phi \qquad \ldots(i)$$

At D,

$$eV_2 = h\nu_2 - \phi \qquad \ldots(ii)$$

Subtracting eq (ii) from (i),

$$eV_1 - eV_2 = h\nu_1 - h\nu_2$$
$$h = \frac{e(V_1 - V_2)}{(\nu_1 - \nu_2)}$$

Question13

Electron beam when accelerated by a voltage of 10 kV , has a de-Broglie wavelength ' λ '. If the voltage is increased to 20 kV then the deBroglie wavelength associated with the electron beam would be

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Options:

A. 4λ

B. 2λ

C. $\frac{\lambda}{2}$

D. $\frac{\lambda}{\sqrt{2}}$

Answer: D

Solution:

The de Broglie wavelength $\lambda = \frac{1.228}{\sqrt{v}}$ (nm) If $v = 10kV$ then it is given that the de Broglie wavelength is λ.

If v is increased to 20 kV , then λ will become $\frac{1}{\sqrt{2}}$ times.

Question14

For two different photosensitive materials having work function ϕ and 2ϕ respectively, are illuminated with light of sufficient energy to emit electrons. If the graph of stopping potential versus frequency is drawn, for these two different photosensitive materials, the ratio of slope of graph for these two materials is

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Options:

A. 1 : 1

B. 1 : 2

C. 1 : 4

D. 4 : 1

Answer: A

Solution:

Step 1: Recall the photoelectric equation

Einstein's photoelectric equation is:

$K_{\max} = hf - \phi$

Stopping potential V_0 is:

$eV_0 = K_{\max} = hf - \phi$

So:

$$V_0 = \frac{h}{e}f - \frac{\phi}{e}$$

This shows V_0 versus f is a **straight line** of the form:

$$V_0 = \left(\frac{h}{e}\right)f - \frac{\phi}{e}.$$

Step 2: Slope of the line

The slope is:

$$\text{slope} = \frac{h}{e}$$

which is **independent** of the material's work function ϕ.

Step 3: Compare the two materials

- Material 1 has work function ϕ.

- Material 2 has work function 2ϕ.

Their lines will have different intercepts (threshold frequency shifts), but the **slopes are the same**.

Hence, the ratio of slopes:

$1 : 1$.

✅ **Correct Answer: Option A — $1 : 1$**

Question15

The energy that should be added to an electron to reduce its de-Broglie wavelength from λ to $\frac{\lambda}{2}$ is n times the initial energy. The value of ' n ' is

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Options:

A. 4

B. 3

C. 2

D. 1

Solution:

Step 1: Relation between momentum and wavelength

De-Broglie wavelength:

$$\lambda = \frac{h}{p}.$$

If wavelength reduces from λ to $\frac{\lambda}{2}$:

$$\lambda' = \frac{\lambda}{2} \quad \Rightarrow \quad p' = \frac{h}{\lambda'} = \frac{h}{\lambda/2} = \frac{2h}{\lambda} = 2p.$$

So new momentum $= 2p$.

Step 2: Kinetic energy in terms of momentum

For non-relativistic electron:

$$E = \frac{p^2}{2m}.$$

Initial energy:

$$E_i = \frac{p^2}{2m}.$$

Final energy:

$$E_f = \frac{p'^2}{2m} = \frac{(2p)^2}{2m} = \frac{4p^2}{2m} = 4E_i.$$

Step 3: Energy that should be added

Energy added:

$$\Delta E = E_f - E_i = 4E_i - E_i = 3E_i.$$

So the added energy is 3 times the initial energy.

Final Answer:

$$n = 3$$

Correct Option: B (3). ✅

Question16

When the electron orbiting in hydrogen atom goes from one orbit to another orbit (principal quantum number $= n$), the de-Broglie wavelength (λ) associated with it is related to n as

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Options:

A. $\lambda \propto \frac{1}{n^2}$

B. $\lambda \propto n^2$

C. $\lambda \propto \frac{1}{n}$

D. $\lambda \propto n$

Answer: D

Solution:

Step 1. Recall Bohr's quantization condition

Bohr's model says:

$mvr = n\hbar \qquad (1)$

And also, de Broglie's condition:

$2\pi r = n\lambda \qquad (2)$

Thus, the circumference of the orbit equals an integer multiple of the de Broglie wavelength.

Step 2. Bohr's orbit radius

For a hydrogen atom,

$r_n = a_0 n^2,$

where a_0 is the Bohr radius.

Step 3. Relation between λ and n

From equation (2):

$\lambda = \frac{2\pi r_n}{n}.$

Substitute $r_n = a_0 n^2$:

$\lambda = \frac{2\pi(a_0 n^2)}{n} = 2\pi a_0 n.$

Step 4. Conclusion

So, the de Broglie wavelength is **directly proportional to** n.

$$\boxed{\lambda \propto n}$$

Correct Option: D ✅

Question17

Photoelectric emission takes place from a certain metal at threshold frequency v. If the radiation of frequency $4v$ is incident on the metal plate, the maximum velocity of the emitted photoelectrons will be ($m =$ mass of photoelectron, $h =$ Planck's constant)

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Options:

A. $\sqrt{\frac{6hv}{m}}$

B. $\sqrt{\frac{3hv}{m}}$

C. $\sqrt{\frac{hv}{m}}$

D. $\sqrt{\frac{5hv}{m}}$

Answer: A

Solution:

Threshold frequency is given as v

Work function $\phi_0 = hv$

Now, $E = K.E. + \phi_0$

$\quad 4hv = \frac{1}{2}mv^2 + hv$

$\therefore \quad \frac{1}{2}mv^2 = 4hv - hv$

$\therefore \quad \frac{1}{2}mv^2 = 3hv$

$\therefore \quad v = \sqrt{\frac{6hv}{m}}$

Question18

The de-Broglie wavelength of a neutron at $27°\text{C}$ is ' λ_0 '. What will be its wavelength at $927°\text{C}$?

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Options:

A. $\frac{\lambda_0}{4}$

B. $\frac{\lambda_0}{3}$

C. $\frac{\lambda_0}{2}$

D. $\frac{3\lambda_0}{2}$

Answer: C

Solution:

Step 1: Recall de Broglie wavelength and thermal relation

The de Broglie wavelength:

$\lambda = \frac{h}{p}$

For a particle in thermal equilibrium, its average kinetic energy is proportional to temperature:

$\frac{1}{2}mv^2 \sim k_B T$

Thus,

$v \propto \sqrt{T}, \quad p = mv \propto \sqrt{T}.$

So:

$\lambda \propto \frac{1}{\sqrt{T}}.$

Step 2: Convert temperatures to Kelvin

- At $27°\text{C}$: $T_1 = 27 + 273 = 300$ K.

- At $927°\text{C}$: $T_2 = 927 + 273 = 1200$ K.

Step 3: Ratio of wavelengths

$$\frac{\lambda_2}{\lambda_1} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{300}{1200}} = \sqrt{\frac{1}{4}} = \frac{1}{2}.$$

So:

$$\lambda_2 = \frac{\lambda_0}{2}.$$

✅ **Final Answer:**

Option C: $\frac{\lambda_0}{2}$

Question19

When a photosensitive metal surface is illuminated with radiation of wavelength ' λ_1 ', the stopping potential is ' V_1 '. If the same surface is illuminated with radiation of wavelength ' $3\lambda_1$ ', the stopping potential is $\frac{V_1}{6}$. The threshold wavelength for the photosensitive metal surface is

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Options:

A. $\frac{3}{2}\lambda_1$

B. $2\lambda_1$

C. $5\lambda_1$

D. $6\lambda_1$

Answer: C

Solution:

From $\frac{hc}{\lambda} - \phi = eV$,

We can write,

$$\frac{hc}{\lambda_1} = eV_1 + \phi \qquad \ldots(i)$$

and

$$\frac{hc}{3\lambda_1} = \frac{eV_1}{6} + \phi \qquad \ldots (ii)$$

Equation (ii) can be rewritten as,

$$\frac{2hc}{\lambda_1} = eV_1 + 6\phi \qquad \ldots (iii)$$

On subtracting equation (i) from (iii), we have $\frac{hc}{\lambda_1} = 5\phi$ and $\phi = \frac{hc}{\lambda_0}$

$$\therefore \quad \lambda_0 = 5\lambda_1$$

Question20

From photoelectric effect experiment, select the correct statement.

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Options:

A. Photoelectric effect can be explained using wave theory of light.

B. The maximum kinetic energy of a photoelectron depends on the intensity of incident light.

C. The stopping potential depends only on the work function of the metal.

D. The saturation current increases as the intensity of incident light increases.

Answer: D

Solution:

1. **Option A:** *Photoelectric effect can be explained using wave theory of light.*

   ❌ Incorrect — The wave theory predicts continuous energy transfer and dependence on intensity, but experiments show cutoff frequency and instantaneous emission. The photoelectric effect requires the photon (particle) theory of light.

2. **Option B:** *The maximum kinetic energy of a photoelectron depends on the intensity of incident light.*

   ❌ Incorrect — Maximum kinetic energy depends on the **frequency** of light, not its intensity. $K_{\max} = h\nu - \phi$. Intensity affects the number of electrons emitted, not their max kinetic energy.

3. **Option C:** *The stopping potential depends only on the work function of the metal.*

   ❌ Incorrect — Stopping potential depends on the **photon energy relative to the work function**:

$$eV_{\text{stop}} = h\nu - \phi$$

So it depends on both frequency and work function (not only work function).

4. **Option D:** *The saturation current increases as the intensity of incident light increases.*

✅ Correct — Higher intensity means more photons per second, which means more emitted electrons if frequency > threshold, so larger saturation current.

✓ **Correct Answer: Option D**

Question21

When photons of energies twice and thrice the work function of a metal are incident on the metal surface one after other, the maximum velocities of the photoelectrons emitted in the two cases are V_1 and V_2 respectively. The ratio $V_1 : V_2$ is

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Options:

A. $\sqrt{3} : \sqrt{2}$

B. $\sqrt{2} : 1$

C. $\sqrt{3} : 1$

D. $1 : \sqrt{2}$

Answer: D

Solution:

Step 1: Recall the photoelectric equation

$$K_{\text{max}} = E_{\text{photon}} - \phi$$

where ϕ is the work function.

Also,

$$K_{\text{max}} = \tfrac{1}{2}mv^2.$$

Step 2: Case 1

Photon energy $E_1 = 2\phi$.

$K_1 = E_1 - \phi = 2\phi - \phi = \phi$.

So

$\frac{1}{2}mV_1^2 = \phi \quad \Rightarrow V_1 = \sqrt{\frac{2\phi}{m}}$

Step 3: Case 2

Photon energy $E_2 = 3\phi$.

$K_2 = 3\phi - \phi = 2\phi$.

So

$\frac{1}{2}mV_2^2 = 2\phi \quad \Rightarrow V_2 = \sqrt{\frac{4\phi}{m}} = 2\sqrt{\frac{\phi}{m}}$.

Step 4: Ratio

$\frac{V_1}{V_2} = \frac{\sqrt{2\phi/m}}{2\sqrt{\phi/m}} = \frac{\sqrt{2}}{2} = \frac{1}{\sqrt{2}}$.

So

$V_1 : V_2 \;=\; 1 : \sqrt{2}$.

✅ **Final Answer:**

Option D — $1 : \sqrt{2}$

Question22

When a light of wavelength λ falls on the emitter of a photocell, maximum speed of emitted photoelectrons is V . If the incident wavelength is changed to $\frac{2\lambda}{3}$, maximum speed of emitted photoelectrons will be :

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Options:

A. $\sqrt{3}$ V

B. $\frac{V}{2}$

C. V

D. $\sqrt{\frac{3}{2}}$ V

Answer: D

Solution:

Step 1: Apply the photoelectric equation for the first case

The kinetic energy of the photoelectrons is related to the incident light frequency (or wavelength) and the work function (ϕ) by the equation:

$$KE_{\max} = hf - \phi = \frac{hc}{\lambda} - \phi$$

The maximum kinetic energy is also given by $\frac{1}{2}mV^2$, where m is the electron mass and V is the maximum speed.

So, for the first case:

$$\frac{1}{2}mV^2 = \frac{hc}{\lambda} - \phi \quad (1)$$

Step 2: Apply the photoelectric equation for the second case

For the second case, the wavelength is changed to $\frac{2\lambda}{3}$, and let the new maximum speed be V'.

$$\frac{1}{2}m(V')^2 = \frac{hc}{\frac{2\lambda}{3}} - \phi = \frac{3hc}{2\lambda} - \phi \quad (2)$$

Step 3: Manipulate the equations to find a relationship

The problem does not provide the work function (ϕ), which implies that either ϕ is zero or there is a specific relationship between the terms. If we assume the work function is zero (which is often the case in simplified problems unless specified otherwise), we can divide equation (2) by equation (1):

$$\frac{\frac{1}{2}m(V')^2}{\frac{1}{2}mV^2} = \frac{\frac{3hc}{2\lambda}}{\frac{hc}{\lambda}}$$

$$\frac{(V')^2}{V^2} = \frac{3}{2}$$

$$(V')^2 = \frac{3}{2} V^2$$

$$V' = \sqrt{\frac{3}{2}} V$$

Answer:

(d) $\sqrt{\frac{3}{2}}$ **V**

Question23

The de-Broglie wavelength (λ) of a particle

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Options:

A. is inversely proportional to impulse.

B. does not depend on impulse.

C. is proportional to mass.

D. is proportional to impulse.

Answer: A

Solution:

The de-Broglie wavelength λ of a particle is given by the formula:

$\lambda = \frac{h}{p}$

where h is Planck's constant and p is the momentum (impulse) of the particle.

From the formula, λ is **inversely proportional** to momentum (impulse).

Correct answer:

Option A: is inversely proportional to impulse.

Question24

Photoelectric emission is observed from a metallic surface for frequencies v_1 and v_2 of the incident light rays $(v_1 > v_2)$. If the maximum values of kinetic energy of the photoelectrons emitted in the two cases are in the ratio of $1 : \mathrm{k}$, then the threshold frequency of metallic surface is

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Options:

A. $\dfrac{\mathrm{kv_2 - v_1}}{\mathrm{k-1}}$

B. $\dfrac{v_2 - v_1}{k}$

C. $\dfrac{v_1 - v_2}{k-1}$

D. $\dfrac{\mathrm{kv_1 - v_2}}{\mathrm{k-1}}$

Answer: D

Solution:

Let the threshold frequency be v_0.

Step 1: Write the photoelectric equation

For incident frequency v, the maximum kinetic energy (K_{max}) of photoelectrons is:
$K_{max} = h(v - v_0)$

where h is Planck's constant.

Step 2: Write equations for the two cases

For v_1:

$$K_1 = h(v_1 - v_0)$$

For v_2:

$$K_2 = h(v_2 - v_0)$$

Step 3: Use the ratio information

Given:

$$\frac{K_1}{K_2} = \frac{1}{k}$$

So,

$$\frac{h(v_1 - v_0)}{h(v_2 - v_0)} = \frac{1}{k}$$

(The h cancels out)

$$\frac{v_1 - v_0}{v_2 - v_0} = \frac{1}{k}$$

Step 4: Rearranging to solve for v_0

Cross-multiply:

$$k(v_1 - v_0) = v_2 - v_0$$

Expand and collect v_0 terms:

$$kv_1 - kv_0 = v_2 - v_0$$

Bring v_0 terms to one side:

$$kv_1 - v_2 = kv_0 - v_0$$

$$kv_1 - v_2 = (k - 1)v_0$$

$$v_0 = \frac{kv_1 - v_2}{k - 1}$$

Step 5: Match with options

This matches **Option D**:

$$\boxed{\frac{kv_1 - v_2}{k - 1}}$$

Question25

On a photosensitive material, when frequency of incident radiation is increased by 20%, maximum kinetic energy of emitted photoelectrons increases from 0.4 eV to 0.7 eV. The work function of the material is

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Options:

A. 3.5 eV

B. 1.1 eV

C. 0.48 eV

D. 0.22 eV

Answer: B

Solution:

We use Einstein's Photoelectric Equation:

K.E. $= hf - \phi$

Let the original frequency of light be f. After a 20% increase, the new frequency becomes $1.2f$.

For the first case (original frequency):

$K_1 = hf - \phi = 0.4$ eV

For the second case (increased frequency):

$K_2 = h \times 1.2f - \phi = 0.7$ eV

Subtract the first equation from the second to find hf:

$[h \times 1.2f - \phi] - [hf - \phi] = 0.7 - 0.4$

This simplifies to:

$0.2hf = 0.3$

So,

$hf = \frac{0.3}{0.2} = 1.5$ eV

Now, use hf to find the work function ϕ:

$\phi = hf - 0.4 = 1.5 - 0.4 = 1.1$ eV

Question26

A light of wavelength λ is incident on a photosensitive surface of negligible work function. The photoelectrons emitted from the surface have de-Broglie wavelength λ_1. Then ratio $\lambda : \lambda_1{}^2$ is

(h = Planck's constant, c = velocity of light, m = mass of electron)

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Options:

A. 4mc : h

B. $2c : h$

C. 2mc : h

D. 2mh : c

Answer: C

Solution:

Energy of photon : $E = \frac{hc}{\lambda}$

Kinetic energy $= K = \frac{hc}{\lambda}$

De- Broglie wavelength : $\lambda_1 = \frac{h}{\sqrt{2mK}}$

$$\lambda_1 = \frac{h\sqrt{\lambda}}{\sqrt{2mhc}}$$

$$\lambda_1^2 = \frac{h^2\lambda}{2mhc}$$

$$\frac{\lambda}{\lambda_1^2} = \frac{2mc}{h}$$

$$\therefore \quad \lambda_1 : \lambda_1^2 = 2mc : h$$

Question27

Light of wavelength ' λ ' falls on a metal having work function $\frac{hc}{\lambda_0}$. Photoelectric effect will take place only if (λ_0 is the threshold wavelength)

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Options:

A. $\lambda \geq \lambda_0$

B. $\lambda \geq 2\lambda_0$

C. $\lambda \leq \lambda_0$

D. $\lambda = 4\lambda_0$

Answer: C

Solution:

The photoelectric effect occurs only when the energy of the incident photon is **greater than or equal to** the work function of the metal.

The energy of the incident photon of wavelength λ is:

$E = \frac{hc}{\lambda}$

The work function (ϕ) is given as:

$\phi = \frac{hc}{\lambda_0}$

For photoelectric emission:

$E \geq \phi$

So,

$\frac{hc}{\lambda} \geq \frac{hc}{\lambda_0}$

Divide both sides by hc:

$\frac{1}{\lambda} \geq \frac{1}{\lambda_0}$

Taking reciprocal (and reversing the inequality since reciprocals of positive numbers reverse the inequality sign):

$\lambda \leq \lambda_0$

Correct option:

Option C: $\lambda \leq \lambda_0$

Question28

A parallel beam of light is incident normally on a plane surface absorbing 50% of the light and reflecting the rest. If the incident beam carries 90 W of power, the force exerted by it on the surface is (C = velocity of light in air $= 3 \times 10^8$ m/s)

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Options:

A. 4.5×10^{-7} N

B. 1.5×10^{-7} N

C. 3×10^{-7} N

D. 9×10^{-7} N

Solution:

Given:

- Power of incident light, $P = 90$ W

- Surface absorbs 50% of the light and reflects 50%

- Speed of light, $c = 3 \times 10^8$ m/s

Let's follow the **NCERT method**:

Step 1: Find the force due to absorption

When light is **absorbed**, the force exerted on the surface is:

$$F_{\text{abs}} = \frac{P_{\text{absorbed}}}{c}$$

Since 50% is absorbed:

$$P_{\text{absorbed}} = 0.5 \times 90 = 45 \text{ W}$$

So,

$$F_{\text{abs}} = \frac{45}{3 \times 10^8} = 1.5 \times 10^{-7} \text{ N}$$

Step 2: Find the force due to reflection

When light is **reflected normally** (for normal incidence and perfect reflection), the change in momentum is **twice** that of absorption.

Force due to **reflection**:

$$F_{\text{ref}} = \frac{2P_{\text{reflected}}}{c}$$

Since 50% is reflected:

$$P_{\text{reflected}} = 0.5 \times 90 = 45 \text{ W}$$

Thus,

$$F_{\text{ref}} = \frac{2 \times 45}{3 \times 10^8} = \frac{90}{3 \times 10^8} = 3 \times 10^{-7} \text{ N}$$

Step 3: Total force exerted

$$F_{\text{total}} = F_{\text{abs}} + F_{\text{ref}}$$

$$F_{\text{total}} = 1.5 \times 10^{-7} \text{ N} + 3 \times 10^{-7} \text{ N}$$

$$F_{\text{total}} = 4.5 \times 10^{-7} \text{ N}$$

Correct answer:

$\boxed{4.5 \times 10^{-7} \text{ N}}$ (Option A)

Question29

An electron accelerated by a potential difference ' V ' has de-Broglie wavelength ' λ '. If the electron is accelerated by a potential difference ' 9 V ', its de-Broglie wavelength will be

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Options:

A. $\frac{\lambda}{4.5}$

B. $\frac{\lambda}{3}$

C. $\frac{\lambda}{2}$

D. λ

Answer: B

Solution:

Given:

An electron accelerated by potential difference V has de-Broglie wavelength λ.

We have to find: The de-Broglie wavelength when it is accelerated by $9V$.

Step 1: Formula for de-Broglie wavelength of an electron

The de-Broglie wavelength λ of an electron accelerated through a potential V is:

$\lambda = \frac{h}{p}$

When an electron is accelerated by V, its kinetic energy $K = eV$.

Momentum:

$K = \frac{1}{2}mv^2 = eV \implies v = \sqrt{\frac{2eV}{m}}$

$p = mv = m\sqrt{\frac{2eV}{m}} = \sqrt{2meV}$

So,

$$\lambda = \frac{h}{\sqrt{2meV}}$$

Step 2: Relationship between wavelength and potential

From the formula:

$$\lambda \propto \frac{1}{\sqrt{V}}$$

Step 3: Compare for V and $9V$

Let λ_1 be for V and λ_2 for $9V$.

$$\frac{\lambda_2}{\lambda_1} = \sqrt{\frac{V}{9V}} = \sqrt{\frac{1}{9}} = \frac{1}{3}$$

$$\lambda_2 = \frac{\lambda_1}{3}$$

Step 4: Conclusion

The answer is:

Option B: $\frac{\lambda}{3}$

Question30

The maximum velocity of the photoelectrons emitted by a metal surface is 9×10^5 m/s. The value of ratio of charge (e) to mass (m) of the photoelectron is 1.8×10^{11} C/kg. The value of stopping potential in volt is

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Options:

A. 2.00

B. 2.25

C. 2.50

D. 3.00

Answer: B

Solution:

Given:

- Maximum velocity of photoelectrons, $v_{max} = 9 \times 10^5$ m/s

- $\dfrac{e}{m} = 1.8 \times 10^{11}$ C/kg

Let the stopping potential be V_0.

Step 1: Kinetic Energy of Photoelectron

The maximum kinetic energy of the photoelectron is given by:

$K_{max} = \frac{1}{2} m v_{max}^2$

Step 2: Stopping Potential Relation

The stopping potential V_0 is related by the equation:

$eV_0 = K_{max}$

So,

$V_0 = \frac{K_{max}}{e}$

Step 3: Substitute for K_{max}/e

Substitute K_{max}:

$V_0 = \frac{\frac{1}{2} m v_{max}^2}{e}$

But $\frac{e}{m}$ is given.

So,

$\frac{m}{e} = \frac{1}{\frac{e}{m}} = \frac{1}{1.8 \times 10^{11}}$

Now,

$V_0 = \frac{1}{2} \cdot \frac{m}{e} (v_{max})^2$

Step 4: Substitute Values

Substitute:

- $v_{max} = 9 \times 10^5$ m/s

- $m/e = \dfrac{1}{1.8 \times 10^{11}}$

So,

$V_0 = \frac{1}{2} \left(\frac{1}{1.8 \times 10^{11}} \right) \left(9 \times 10^5 \right)^2$

Step 5: Calculate $(9 \times 10^5)^2$

$(9 \times 10^5)^2 = 81 \times 10^{10} = 8.1 \times 10^{11}$

Step 6: Substitute and Calculate

$V_0 = \frac{1}{2} \times \frac{1}{1.8 \times 10^{11}} \times (8.1 \times 10^{11})$

$V_0 = \frac{1}{2} \times \frac{8.1 \times 10^{11}}{1.8 \times 10^{11}}$

$V_0 = \frac{1}{2} \times \frac{8.1}{1.8}$

$V_0 = \frac{1}{2} \times 4.5 = 2.25$ V

Final Answer:

Option B: 2.25 volts

Question31

Light of wavelength λ strikes a photoelectric surface and electrons are ejected with energy E . If E is to be increased to twice the original value, the wavelength changes to λ_1

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Options:

A. $\lambda_1 < \lambda/2$

B. $\lambda_1 = \lambda$

C. $\lambda_1 > \lambda/2$

D. $\lambda_1 = \lambda/2$

Answer: C

Solution:

Let us start with the **photoelectric equation**:

$K = h\nu - \phi$

where

K = Kinetic energy of ejected electron

h = Planck's constant

ν = Frequency of incident light

ϕ = Work function of the metal

Since $\nu = \dfrac{c}{\lambda}$, the equation becomes:

$$K = \frac{hc}{\lambda} - \phi$$

Let the original kinetic energy be E:

$$E = \frac{hc}{\lambda} - \phi \qquad \cdots (1)$$

Now, E is **doubled** to $2E$ by changing the wavelength to λ_1:

$$2E = \frac{hc}{\lambda_1} - \phi \qquad \cdots (2)$$

Step 1: Express ϕ in terms of E and λ

From (1):

$$\phi = \frac{hc}{\lambda} - E$$

Step 2: Substitute value of ϕ in (2):

$$2E = \frac{hc}{\lambda_1} - \left(\frac{hc}{\lambda} - E \right)$$

Simplify:

$$2E = \frac{hc}{\lambda_1} - \frac{hc}{\lambda} + E$$

Bring E to the left:

$$2E - E = \frac{hc}{\lambda_1} - \frac{hc}{\lambda}$$

$$E = \frac{hc}{\lambda_1} - \frac{hc}{\lambda}$$

Step 3: Rearranging for $\dfrac{1}{\lambda_1}$

Add $\dfrac{hc}{\lambda}$ to both sides:

$$E + \frac{hc}{\lambda} = \frac{hc}{\lambda_1}$$

Divide both sides by hc:

$$\frac{E}{hc} + \frac{1}{\lambda} = \frac{1}{\lambda_1}$$

Recall from equation (1):

$$E = \frac{hc}{\lambda} - \phi \implies \frac{E}{hc} = \frac{1}{\lambda} - \frac{\phi}{hc}$$

Substitute:

$$\left(\frac{1}{\lambda} - \frac{\phi}{hc}\right) + \frac{1}{\lambda} = \frac{1}{\lambda_1}$$

$$\frac{2}{\lambda} - \frac{\phi}{hc} = \frac{1}{\lambda_1}$$

But we are just comparing, observe from earlier:

$$\frac{E}{hc} + \frac{1}{\lambda} = \frac{1}{\lambda_1}$$

From (1) again, $E = \frac{hc}{\lambda} - \phi$:

So,

$$\frac{E}{hc} = \frac{1}{\lambda} - \frac{\phi}{hc}$$

Plug in:

$$\frac{1}{\lambda_1} = \left(\frac{1}{\lambda} - \frac{\phi}{hc}\right) + \frac{1}{\lambda}$$

$$\Rightarrow \frac{1}{\lambda_1} = \frac{2}{\lambda} - \frac{\phi}{hc}$$

Compare to $\lambda/2$:

For $\lambda_1 = \lambda/2$:

$$\frac{1}{\lambda_1} = \frac{2}{\lambda}$$

But in our equation:

$$\frac{1}{\lambda_1} = \frac{2}{\lambda} - \frac{\phi}{hc} < \frac{2}{\lambda}$$

Therefore,

$$\lambda_1 > \frac{\lambda}{2}$$

Final Answer:

Option C: $\boxed{\lambda_1 > \lambda/2}$

Question32

In a photoelectric experiment, if the intensity of incident light is doubled and the frequency is kept slightly greater than threshold frequency, then the saturation photoelectric current

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Options:

A. remains constant

B. is halved

C. is doubled

D. becomes four times

Answer: C

Solution:

The correct answer is: **Option C: is doubled**

Explanation:

- The *saturation photoelectric current* is the maximum current obtained when all the emitted photoelectrons are collected.

- The number of photoelectrons emitted per second depends on the number of photons incident per second, i.e., it is **directly proportional to the intensity** of incident light (provided frequency is above threshold).

- If the intensity is **doubled** (and frequency > threshold frequency), **twice as many photons** hit the metal surface per second, so twice as many electrons are emitted per second.

- Hence, the *saturation current* is **doubled**.

Thus, doubling the intensity (keeping frequency constant and just above threshold) **doubles** the saturation photoelectric current.

So, the answer is Option C.

Question33

Kinetic energy of a proton is equal to energy E of a photon. Let ' λ_1 ' be the de-Broglie wavelength of proton and ' λ_2 ' be the wavelength of photon. If $\left(\frac{\lambda_1}{\lambda_2} \right) \propto E^n$ then the value of ' n ' is

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Options:

A. 1

B. 2

C. 5

D. 0.5

Answer: D

Solution:

If E is the kinetic energy of the proton, then

$E = \dfrac{p^2}{2\,m}$

where p is the momentum and m is the mass of proton

$\therefore \quad p = \sqrt{2mE}$

$\therefore \quad \lambda_1 = \dfrac{h}{p} = \dfrac{h}{\sqrt{2mE}}$

Similarly, for a photon, $E = \dfrac{hc}{\lambda_2}$

$\therefore \quad \lambda_2 = \dfrac{hc}{E}$

$\therefore \quad \dfrac{\lambda_1}{\lambda_2} = \dfrac{h}{\sqrt{2mE}} \times \dfrac{E}{hc} = \dfrac{1}{c}\sqrt{\dfrac{E}{2\,m}}$

$\therefore \quad \dfrac{\lambda_1}{\lambda_2} \propto E^{1/2} \Rightarrow n = 0.5$

Question34

A point source of light is used in a photoelectric effect. If the source is removed farther from the emitting metal, then the stopping potential will

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Options:

A. increase.

B. decrease.

C. remain constant.

D. either increase or decrease.

Answer: C

Solution:

As the source is removed farther from the emitting metal, the intensity of light will decrease. As stopping potential does not depend on the intensity of light, it will remain constant.

Question35

When an electron orbiting in hydrogen atom in its ground state jumps to higher excited state, the de-Broglie wavelength associated with it

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Options:

A. will become zero.

B. will remain same.

C. will decrease.

D. will increase.

Answer: D

Solution:

In a hydrogen atom, according to **Bohr's theory**, when an electron moves to a **higher excited state:**

- Its orbit radius increases as

$$r_n \propto n^2$$

- Its **momentum decreases** because

$$p_n = \frac{nh}{2\pi r_n} \propto \frac{1}{n}$$

- De-Broglie wavelength is

$$\lambda = \frac{h}{p} \propto n$$

Thus, **when the electron jumps to a higher orbit (larger n), its de-Broglie wavelength increases.**

✅ **Correct Answer: D — will increase.**

Question36

The figure shows the variation of photocurrent with anode potential for four different radiations. Let I_a, I_b, I_c and I_d be the intensities for the curves a, b, c and d respectively [f_a, f_b, f_c and f_d are frequencies respectively]
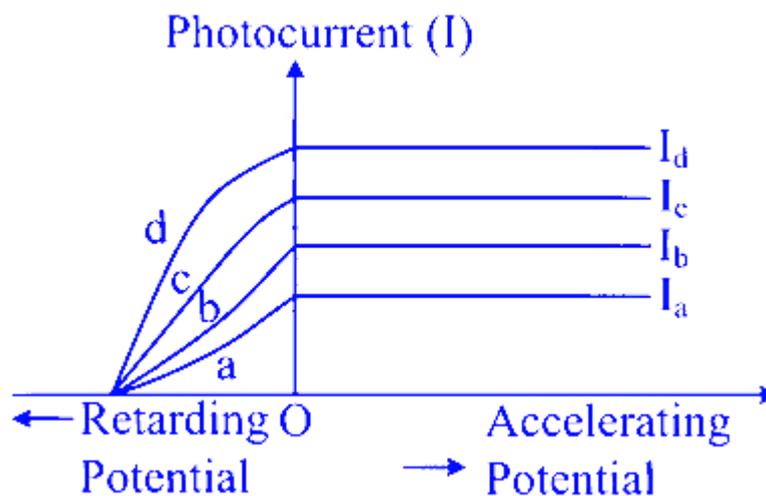
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Options:

A. $f_a = f_b > f_c > f_d$ and $I_a = I_b > I_c > I_d$
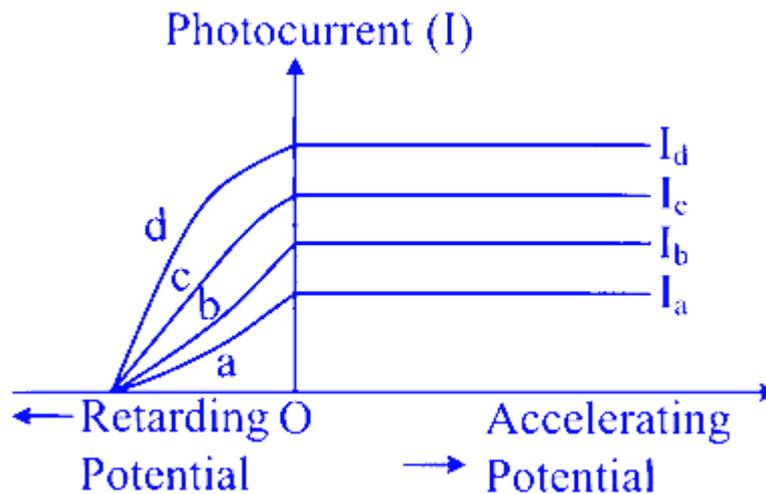
B. $f_a < f_b > f_c = f_d$ and $I_a = I_b > I_c > I_d$

C. $f_a = f_b = f_c = f_d$ and $I_a < I_b < I_c < I_d$

D. $f_a > f_b > f_c > f_d$ and $I_a = I_b = I_c = I_d$

Answer: C

Solution:

Since the stopping potential is same, they all have same frequency i.e., $f_a = f_b = f_c = f_d$

From figure Photocurrent is highest for d followed by c, b and a.

$\therefore \quad I_a < I_b < I_c < I_d$

Question37

When a certain metallic surface is illuminated with monochromatic light wavelength λ, the stopping potential for photoelectric current is $4\,V_0$. When the same surface is illuminated with light of wavelength 3λ, the stopping potential is V_0. The threshold wavelength for this surface for photoelectric effect is

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Options:

A. 9λ

B. $\frac{\lambda}{9}$

C. 3λ

D. $\frac{\lambda}{3}$

Answer: A

Solution:

Using Einstein's photoelectric equation,

$$\mathrm{h}v = \phi_0 + \mathrm{KE}_{\mathrm{max}}$$

$$\therefore \quad \frac{\mathrm{hc}}{\lambda} = \phi_0 + e\left(4\,\mathrm{V}_0\right) \quad \text{.... (i)} \left(\because \mathrm{KE}_{\mathrm{max}} = \mathrm{eV}_{\mathrm{s}}\right)$$

Also, $\frac{\mathrm{hc}}{3\lambda} = \phi_0 + \mathrm{eV}_0$ .... (ii)

Subtracting equation (i) from $4\times$ equation (ii) we get,

$\left(\frac{4}{3} - 1\right)\frac{\mathrm{hc}}{\lambda} = 4\phi_0 - \phi_0$ or $\phi_0 = \frac{\mathrm{hc}}{9\lambda}$

But $\phi_0 = \frac{\mathrm{hc}}{\lambda_0}$, where λ_0 is the threshold wavelength, hence $\lambda_0 = 9\lambda$.

Hence, option (A) is correct.

Question38

The stopping potential as a function of frequency of incident radiation is plotted for two different photoelectric surfaces A and B. The graph shows that the work function of A is
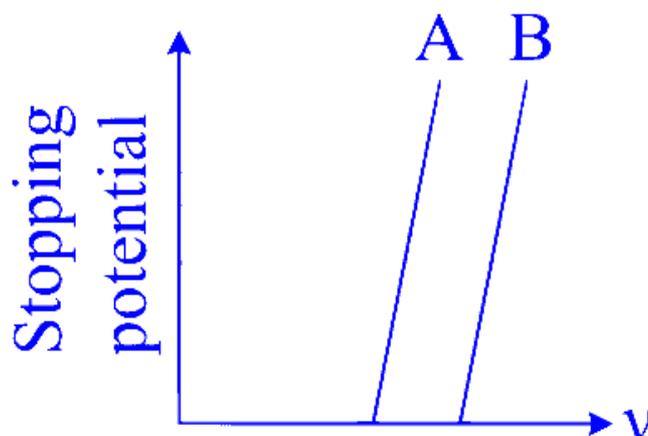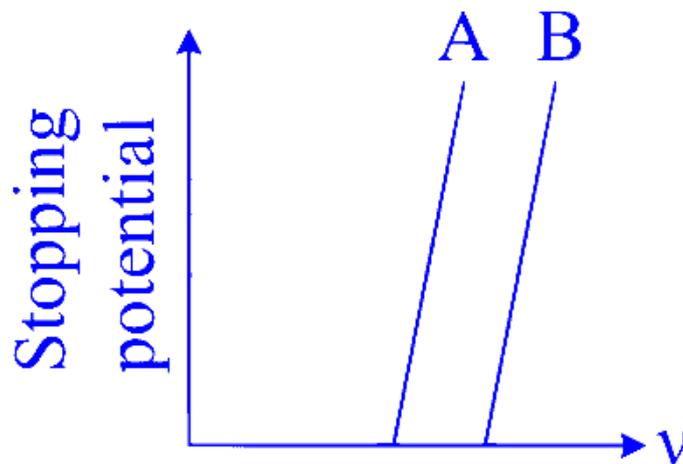
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Options:

A. greater than that of B.

B. smaller than that of B.

C. same as that of B.

D. that no comparison can be made from the graphs.

Answer: B

Solution:

From the given graph,

Threshold frequency (ν_0) of A is less than B.

$\therefore$ Work function $(h\nu_0)$ of A is smaller than that of B.

Question39

Two photons having energies twice and thrice the work function of metal are incident one after another on the metal surface. Then the ratio of maximum velocities of the photoelectrons emitted in the two cases is respectively

Options:

A. $\sqrt{3} : 3$

B. $\sqrt{2} : \sqrt{3}$

C. $1 : \sqrt{2}$

D. $\sqrt{3} : 1$

Answer: C

Solution:

$K \cdot E_{\max} = h\nu - \phi_0$

Given: $E_1 = 2\phi_0$ and $E_2 = 3\phi_0$

$\Rightarrow K \cdot E_1 = 2\phi_0 - \phi_0 = \phi_0$

$\Rightarrow K \cdot E_2 = 3\phi_0 - \phi_0 = 2\phi_0$

but, $K \cdot E_1 = \dfrac{1}{2}mv_1^2$ and $K \cdot E_2 = \dfrac{1}{2}mv_2^2$

$\therefore \quad \dfrac{K \cdot E_1}{K \cdot E_2} = \dfrac{V_1^2}{V_2^2} = \dfrac{1}{2}$

$\therefore \quad \dfrac{V_1}{V_2} = \dfrac{1}{\sqrt{2}}$

Question40

Electrons are accelerated through a potential difference of 16 kV . If the potential difference is increased to 64 kV , then de-Broglie wavelength associated with electron will

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Options:

A. remain same.

B. becomes half.

C. becomes four time.

D. becomes quarter.

Answer: B

Solution:

When electrons are accelerated through a potential difference V, their de-Broglie wavelength is

$$\lambda = \frac{h}{\sqrt{2meV}}$$

So,

$$\lambda \propto \frac{1}{\sqrt{V}}$$

Given:

Initial accelerating voltage:

$$V_1 = 16\,\text{kV}$$

New accelerating voltage:

$$V_2 = 64\,\text{kV} = 4V_1$$

Ratio of wavelengths

$$\frac{\lambda_2}{\lambda_1} = \sqrt{\frac{V_1}{V_2}}$$

Substitute:

$$\frac{\lambda_2}{\lambda_1} = \sqrt{\frac{16}{64}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

Thus the new wavelength is:

$$\lambda_2 = \frac{1}{2}\lambda_1$$

✅ **Correct Answer: B — becomes half**

Question41

In case of photoelectric effect, the graph of measured stopping potential (V_0) against frequency 'v' of incident light is a straight line. The slope of this line multiplied by the charge of electron (e) gives

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Options:

A. the work function of the metal.

B. the Planck's constant.

C. the maximum kinetic energy of the ejected electrons.

D. the threshold frequency for photoejection from the metal.

Answer: B

Solution:

The slope of the graph of the stopping potential V_0 versus the frequency v of the incident light in the photoelectric effect is given by the equation:

$V_0 = \frac{h}{e}v - \frac{\phi}{e}$

where:

V_0 is the stopping potential,

h is Planck's constant,

e is the charge of the electron,

v is the frequency of the incident light,

ϕ is the work function of the metal.

From this equation, it can be observed that the slope of the line is $\frac{h}{e}$. When this slope is multiplied by the charge of the electron (e), the product is the Planck's constant (h):

$\left(\frac{h}{e}\right)e = h$

Therefore, the slope of the line multiplied by the charge of the electron gives Planck's constant.

Correct answer: Option B - the Planck's constant.

Question42

A photoelectric surface is illuminated successively by monochromatic light of Wavelength λ and $(\lambda/3)$. If the maximum kinetic energy of the emitted photoelectrons in the second case is 4 times that in the first case, the work function of the surface of the material is (h = Planck's constant, c = speed of light)

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Options:

A. $\frac{hc}{\lambda}$

B. $\frac{hc}{2\lambda}$

C. $\frac{hc}{3\lambda}$

D. $\frac{3hc}{\lambda}$

Answer: C

Solution:

1st case:

$$E_0 = \frac{hc}{\lambda} - \phi \quad \text{.... (i)}$$

2nd case:

$$4E_0 = \frac{hc}{\frac{\lambda}{3}} - \phi \quad \text{.... (ii)}$$

$$\therefore \quad \frac{4E_0}{E_0} = \frac{\frac{3hc}{\lambda} - \phi}{\frac{hc}{\lambda} - \phi} \quad \text{... [From (i) and (ii)]}$$

$$\frac{4hc}{\lambda} - 4\phi = \frac{3hc}{\lambda} - \phi$$

$$\phi = \frac{hc}{3\lambda}$$

Question43

If the frequency of incident radiation (ν) is increased, keeping other factors constant, the stopping potential ($\nu > \nu_0$, threshold frequency)

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Options:

A. increases

B. decreases

C. remains constant

D. suddenly becomes zero

Answer: A

Solution:

$$eV_s = h\nu - W_0$$

$\therefore$ If ν increases, V_s will increase.

Question44

If the potential difference used to accelerate electrons is doubled. By what factor does the deBroglie wavelength (λ) associated with the electrons change?

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Options:

A. λ is increased to $\sqrt{2}$ times.

B. λ is increased to $\frac{1}{\sqrt{2}}$ times.

C. λ is decreased to $\frac{1}{\sqrt{2}}$ times.

D. λ is decreased to $\sqrt{2}$ times.

Answer: C

Solution:

From $\lambda = \frac{h}{\sqrt{2mqV}}$,

$\lambda \propto \frac{1}{\sqrt{v}}$

If potential difference is doubled,

$\lambda \propto \frac{1}{\sqrt{2\,V}}$

$\therefore$ λ is decreased by $\frac{1}{\sqrt{2}}$ times.

Question45

A photoelectric surface is illuminated successively by monochromatic light of wavelength ' λ ' and $\left(\frac{\lambda}{2}\right)$. If the maximum kinetic energy of the emitted photoelectrons in the first case is one-fourth that in the second case, the work function of the surface of the material is (c = speed of light, h = Planck's constant)

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Options:

A. $\frac{2hc}{\lambda}$

B. $\frac{hc}{\lambda}$

C. $\frac{2hc}{3\lambda}$

D. $\frac{hc}{3\lambda}$

Answer: C

Solution:

$E_1 = \dfrac{hc}{\lambda} - \phi$ .... (i)

$E_2 = \dfrac{hc}{\lambda/2} - \phi = \dfrac{2hc}{\lambda} - \phi$ .... (ii)

Given, $E_1 = \dfrac{E_2}{4}$

$\therefore \quad 4E_1 = E_2$ .... (iii)

From (ii) and (iii),

$4E_1 = \dfrac{2hc}{\lambda} - \phi$

$4\left(\dfrac{hc}{\lambda} - \phi\right) = \dfrac{2hc}{\lambda} - \phi$ .... [Substituting from (i)]

$\therefore \quad \dfrac{4hc}{\lambda} - 4\phi = \dfrac{2hc}{\lambda} - \phi$

$\therefore \quad 3\phi = \dfrac{2hc}{\lambda}$

$\therefore \quad \phi = \dfrac{2hc}{3\lambda}$

Question46

When a photosensitive surface is irradiated by lights of wavelengths ' λ_1 ' and ' λ_2 ', kinetic energies of the emitted photoelectrons is ' E_1 ' and ' E_2 ' respectively. The work function of the photosensitive surface is

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Options:

A. $\dfrac{(E_2\lambda_2 - E_1\lambda_1)}{(\lambda_2 - \lambda_1)}$

B. $\dfrac{(E_1\lambda_1 + E_2\lambda_2)}{(\lambda_2 - \lambda_1)}$

C. $\dfrac{(E_1\lambda_1 - E_2\lambda_2)}{(\lambda_2 - \lambda_1)}$

D. $\dfrac{(E_2\lambda_2 + E_1\lambda_1)}{(\lambda_1 - \lambda_2)}$

Answer: C

Solution:

From Einstein's photoelectric equation,

$$E_1 = \frac{hc}{\lambda_1} - W_0$$

$$\therefore \quad E_1\lambda_1 = hc - W_0\lambda_1$$

$$E_2 = \frac{hc}{\lambda_2} - W_0$$

$$\therefore \quad hc = E_1\lambda_1 + W_0\lambda_1 \quad \text{.... (i)}$$

$$\therefore \quad E_2\lambda_2 = hc - W_0\lambda_2$$

$$\Rightarrow hc = E_2\lambda_2 + W_0\lambda_2 \quad \text{.... (ii)}$$

From equations (i) and (ii),

$$E_1\lambda_1 + W_0\lambda_1 = E_2\lambda_2 + W_0\lambda_2$$

$$\therefore \quad E_1\lambda_1 - E_2\lambda_2 = W_0(\lambda_2 - \lambda_1)$$

$$\therefore \quad W_0 = \frac{E_1\lambda_1 - E_2\lambda_2}{\lambda_2 - \lambda_1}$$

Question47

In photoelectric effect, the photocurrent

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Options:

A. decreases with increase in frequency of incident photon.

B. increases with increase in frequency of incident photon.

C. does not depend on the frequency of photon but depends only on the intensity of incident light.

D. depends both on intensity and frequency of incident radiation.

Answer: C

Solution:

Photocurrent is independent of the frequency of photon. However when intensity of incident photon increases number of electrons emitted from the surface also increases, thereby increasing photocurrent.

Question48

If the potential difference used to accelerate electrons is increased four times, by what factor does the de-Broglie wavelength associated with the electrons change?

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Options:

A. Wavelength increased two times

B. Wavelength decreased to half

C. Wavelength increased four times

D. Wavelength remains the same

Answer: B

Solution:

For electrons accelerated through a potential difference V, the de-Broglie wavelength is:

$$\lambda = \frac{h}{\sqrt{2meV}}$$

So:

$$\lambda \propto \frac{1}{\sqrt{V}}$$

Voltage increased four times

If:

$$V_2 = 4V_1$$

Then:

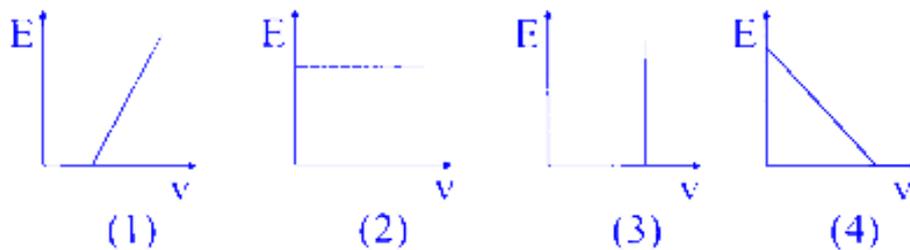$$\frac{\lambda_2}{\lambda_1} = \sqrt{\frac{V_1}{V_2}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

So the new wavelength is:

$$\lambda_2 = \frac{1}{2}\lambda_1$$

Question49

Using Einstein's photoelectric equation, the graph between kinetic energy of emitted photoelectrons and the frequency of incident radiation is shown correctly by graph

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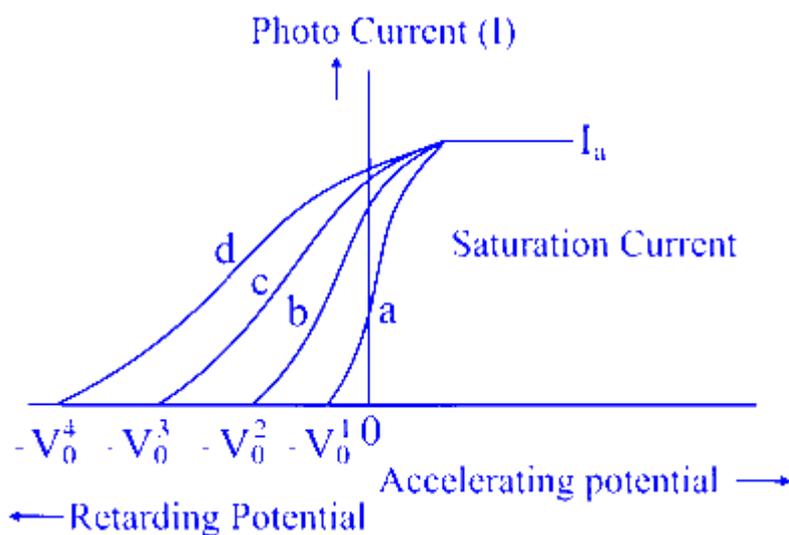
Options:

A. 1

B. 2

C. 3

D. 4

Answer: A

Solution:

Photoelectric equation, K.E. max $= h\nu - \phi$ Comparing with equation of straight line, $y = mx + c$. The graph of K.E.max vs v is a straight line with slope 'h'.

Question50

The figure shows the variation of photocurrent with anode potential for four different radiations. Let f_a, f_b, f_c and f_d be the frequencies for the curves a, b, c and d respectively

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Options:

A. $f_a > f_b > f_c > f_d$

B. $f_a < f_b < f_c < f_d$

C. $f_a > f_b < f_c = f_d$

D. $f_a = f_b > f_c > f_d$

Answer: B

Solution:

We know stopping potential is directly proportional to the frequency of the incoming radiation. This means curve 'a' has the highest frequency and 'd' the lowest.

$\therefore \quad f_a < f_b < f_c < f_d$

Question51

The gyromagnetic ratio and Bohr magneton are given respectively by [Given → e = charge on electron, m = mass of electron, h = Planck's constant]

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Options:

A. $\dfrac{e}{2\,m}$, $\dfrac{eh}{4\pi\,m}$

B. $\dfrac{eh}{4\pi\,m}$, $\dfrac{e}{2\,m}$

C. $\dfrac{2\,m}{e}$, $\dfrac{4\pi\,m}{eh}$

D. $\dfrac{4\pi\,m}{eh}$, $\dfrac{2\,m}{e}$

Answer: A

Solution:

The gyromagnetic ratio is given by the expression:

$\dfrac{e}{2m}$

This ratio describes the magnetic moment of a system per unit angular momentum. It is especially prominent in the context of electron spin and nuclear magnetic resonance.

The Bohr magneton, which represents the natural unit of the magnetic moment in atomic physics, is given by:

$\dfrac{e\hbar}{2m}$

where $\hbar$ is the reduced Planck's constant, defined as $\hbar = \dfrac{h}{2\pi}$.

For the given options, the correct expressions describing the gyromagnetic ratio and the Bohr magneton are found in Option A:

Gyromagnetic Ratio: $\dfrac{e}{2m}$

Bohr Magneton: $\frac{eh}{4\pi m}$ (since $\hbar = \frac{h}{2\pi}$, this simplifies to the Bohr magneton from the definition with $\hbar$)

Thus, Option A is the correct choice which matches these definitions.

Question52

Two identical photocathodes receive light of frequencies ' n_1 ' and ' n_2 '. If the velocities of the emitted photoelectrons of mass ' m ' are ' V_1 ' and ' V , respectively, then ($h = $ Planck's constant)

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Options:

A. $V_1 + V_2 = \left[\frac{2\,h}{m} (n_1 + n_2) \right]^{1/2}$

B. $V_1 - V_2 = \left[\frac{2\,h}{m} (n_1 - n_2) \right]^{1/2}$

C. $V_1^2 + V_2^2 = \frac{2\,h}{m} (n_1 + n_2)$

D. $V_1^2 - V_2^2 = \frac{2\,h}{m} (n_1 - n_2)$

Answer: D

Solution:

To analyze the situation, we will use the photoelectric equation, which describes the kinetic energy of the emitted photoelectrons due to incident light of a certain frequency. The equation is:

$K.E. = \frac{1}{2} m V^2 = h\nu - \phi$

where $K.E.$ is the kinetic energy of the emitted photoelectrons, m is the mass of the electrons, V is their velocity, h is Planck's constant, ν is the frequency of the incident light, and ϕ is the work function of the photocathode (which is the same for both as they are identical).

For two identical photocathodes receiving light of frequencies ν_1 and ν_2, the kinetic energies of the emitted electrons are:

$\frac{1}{2}mV_1^2 = h\nu_1 - \phi$

$\frac{1}{2}mV_2^2 = h\nu_2 - \phi$

Subtracting equation 2 from equation 1 gives:

$\frac{1}{2}mV_1^2 - \frac{1}{2}mV_2^2 = h(\nu_1 - \nu_2)$

Simplifying this, we get:

$\frac{1}{2}m(V_1^2 - V_2^2) = h(\nu_1 - \nu_2)$

Rearranging terms, the equation becomes:

$V_1^2 - V_2^2 = \frac{2h}{m}(\nu_1 - \nu_2)$

Thus, the correct relation for the given scenario is:

Option D:

$V_1^2 - V_2^2 = \frac{2h}{m}(\nu_1 - \nu_2)$

Question53

The kinetic energy of an electron is increased by 2 times, then the de-Broglie wavelength associated with it changes by a factor.

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Options:

A. $\frac{1}{3}$

B. $\frac{1}{\sqrt{3}}$

C. 3

D. $\sqrt{3}$

Answer: B

Solution:

Kinetic Energy, $E = \frac{1}{2}mv^2 = \frac{1}{2}\frac{(mv)^2}{m} = \frac{p^2}{2\,m}$

$\therefore \quad p = \sqrt{2mE} \quad$ ..... (i)

De-Broglie wavelength,

$\lambda = \dfrac{h}{p} = \dfrac{h}{\sqrt{2mE}} \quad$ .... [from (i)]

$\Rightarrow \lambda \propto \dfrac{1}{\sqrt{E}}$

$\therefore \quad$ When kinetic energy is increased by 2 times, $E_2 = E_1 + 2E_1 = 3E_1$

$\therefore \quad \lambda$ changes by factor of $\frac{1}{\sqrt{3}}$

Question54

A photosensitive metallic surface has work function ϕ. If photon of energy 3ϕ falls on the surface, the electron comes out with a maximum velocity of 6×10^6 m/s. When the photon energy is increased to 9ϕ, then maximum velocity of photoelectrons will be

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Options:

A. 12×10^6 m/s

B. 6×10^6 m/s

C. 3×10^6 m/s

D. 24×10^6 m/s

Answer: A

Solution:

For photoelectric effect,

$K.E_{max} = E - \phi_0$ .... (i)

Given: $E_1 = 3\phi_0$ and $E_2 = 9\phi_0$

From (i),

$K.E_1 = 3\phi_0 - \phi_0 = 2\phi_0$
$K \cdot E_2 = 9\phi_0 - \phi_0 = 8\phi_0$

But, $K \cdot E_1 = \frac{1}{2}mv_1^2$ and $K \cdot E_2 = \frac{1}{2}mv_2^2$

$\therefore \quad \dfrac{K \cdot E_1}{K \cdot E_2} = \dfrac{v_1^2}{v_2^2} = \dfrac{1}{4}$

$\therefore \quad v_2 = 2v_1$

$\quad v_2 = 2 \times 6 \times 10^6 = 12 \times 10^6 \text{ m/s}$

Question55

The threshold frequency of a metal is ' F_0 '. When light of frequency $2F_0$ is incident on the metal plate, the maximum velocity of photoelectron is ' V_1 '. When the frequency of incident radiation is increased to ' $5 F_0$ ', the maximum velocity of photoelectrons emitted is ' V_2 '. The ratio of V_1 to V_2 is

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Options:

A. $\frac{1}{8}$

B. $\frac{1}{16}$

C. $\frac{1}{4}$

D. $\frac{1}{2}$

Answer: D

Solution:

$$KE_{max} = hF - F_0$$

When, $F = 2F_0$

$$\frac{1}{2}mV_1^2 = 2hF_0 - F_0 = F_0$$

When, $F = 5F_0$

$$\frac{1}{2}mVV_2^2 = 5hF_0 - F_0 = 4F_0$$

$\therefore \quad \left(\frac{V_1}{V_2}\right)^2 = \frac{F_0}{4F_0}$

$\therefore \quad \frac{V_1}{V_2} = \frac{1}{2}$

Question56

For a photosensitive material, work function is ' W_0 ' and stopping potential is ' V '. The wavelength of incident radiation is (h = Planck's constant, c = velocity of light, e = electronic charge)

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Options:

A. $\frac{h^2 c^2}{W_0 + eV}$

B. $\frac{hc}{W_0}$

C. $\frac{hcV}{W_0}$

D. $\frac{hc}{W_0 + eV}$

Answer: D

Solution:

From Einstein's photoelectric equation, we can write,
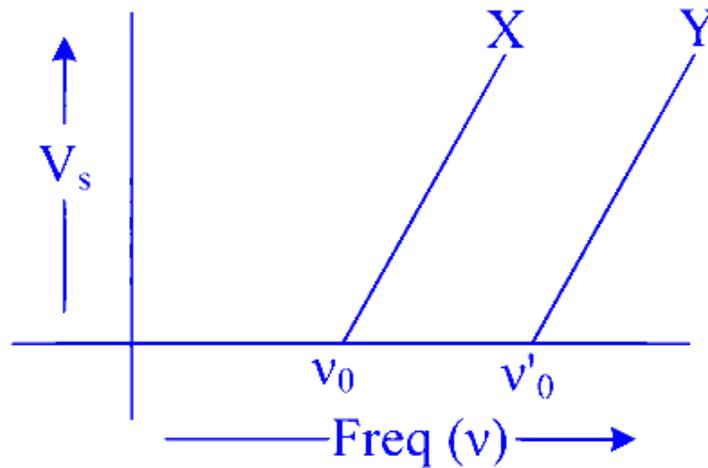
$eV = \frac{hc}{\lambda} - W_0$

$\therefore \quad \frac{hc}{\lambda} = W_0 + eV$

$\therefore \quad \lambda = \frac{hc}{W_0 + eV}$

Question57

The graph of stopping potential ' V_s ' against frequency ' v ' of incident radiation is plotted for two different metals ' X ' and ' Y ' as shown in graph. ' ϕ_x ' and ' ϕ_y ' are work functions of ' x ' and ' Y ' respectively then

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Options:

A. $\phi_x = \phi_y$

B. $\phi_x < \phi_y$

C. $\phi_x > \phi_y$

D. $\phi_x = \phi_y = 0$

Answer: B

Solution:

We know

$\phi = h v_0 \quad \Rightarrow \phi \propto v_0$

Also,

$v_0 < v'_0 \quad$ ... (From graph)

$\therefore \quad \phi_x < \phi_y$

Question58

The frequency of incident light falling on a photosensitive material is doubled, the K.E. of the emitted photoelectrons will be

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Options:

A. unchanged.

B. two times its initial value.

C. more than two times its initial value.

D. less than two times its initial value.

Answer: C

Solution:

The kinetic energy of emitted photoelectrons from a photosensitive material is determined by the equation:

$$K.E_{max} = h\nu - W$$

When the frequency (ν) of the incident light is doubled, the equation becomes:

$$
\begin{aligned}
K.E_{max} &= h(2\nu) - W \\
&= 2h\nu - 2W + W \\
&= 2(h\nu - W) + W \\
&= 2K.E_{initial} + W
\end{aligned}
$$

Thus, the maximum kinetic energy of the emitted photoelectrons is more than twice the initial value.

Question59

When the electron orbiting in hydrogen atom in its ground state moves to the third excited state, the de-Broglie wavelength associated with it

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Options:

A. becomes zero.

B. remains unchanged.

C. will decrease.

D. will increase.

Answer: D

Solution:

To determine how the de Broglie wavelength of an electron changes when it transitions from the ground state to the third excited state in a hydrogen atom, we need to analyze the relationship between the de Broglie wavelength and the principal quantum number n.

Principal Quantum Number and Energy Levels:

Ground State: $n = 1$

First Excited State: $n = 2$

Second Excited State: $n = 3$

Third Excited State: $n = 4$

So, the electron transitions from $n = 1$ to $n = 4$.

De Broglie Wavelength in the Bohr Model:

In the Bohr model, the de Broglie wavelength λ_n of an electron in the nth orbit is given by:

$\lambda_n = \frac{h}{mv_n}$

Where:

h is Planck's constant.

m is the mass of the electron.

v_n is the velocity of the electron in the nth orbit.

Velocity of the Electron:

The velocity v_n is inversely proportional to n:

$v_n = \frac{v_1}{n}$

Substituting v_n into λ_n:

$$\lambda_n = \frac{h}{mv_n} = \frac{h}{m\left(\frac{v_1}{n}\right)} = n\left(\frac{h}{mv_1}\right) = n\lambda_1$$

This shows that the de Broglie wavelength is directly proportional to the principal quantum number n:

$$\lambda_n = n\lambda_1$$

Conclusion:

As the electron moves from the ground state ($n = 1$) to the third excited state ($n = 4$), the de Broglie wavelength increases by a factor of 4:

$$\lambda_4 = 4\lambda_1$$

Answer: Option D – The de Broglie wavelength will increase.

Answer: Will increase.

Question60

The ratio of the wavelength of a photon of energy ' E ' to that of the electron of same energy is (m = mass of an electron, c = speed of light, h = Planck's constant)

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Options:

A. $\sqrt{\frac{m}{cE}}$

B. $\sqrt{\frac{2\,m}{cE}}$

C. $c\sqrt{\frac{m}{E}}$

D. $c\sqrt{\frac{2m}{E}}$

Answer: D

Solution:

To determine the ratio of the wavelength of a photon to that of an electron, both having the same energy E, we'll use the following expressions:

Wavelength of a photon:

The energy E of a photon can be expressed using the equation:

$$E = \frac{hc}{\lambda_{\text{photon}}}$$

where h is Planck's constant, c is the speed of light, and λ_{photon} is the wavelength of the photon. Solving for the wavelength:

$$\lambda_{\text{photon}} = \frac{hc}{E}$$

Wavelength of an electron:

Using de Broglie's wavelength formula, the wavelength $\lambda_{\text{electron}}$ of an electron is:

$$\lambda_{\text{electron}} = \frac{h}{p}$$

The energy E of the electron is given by:

$$E = \frac{p^2}{2m}$$

Solving for p, we get:

$$p = \sqrt{2mE}$$

Substituting p into the expression for the wavelength:

$$\lambda_{\text{electron}} = \frac{h}{\sqrt{2mE}}$$

Ratio of the wavelengths:

The ratio of the wavelength of the photon to that of the electron is:

$$\frac{\lambda_{\text{photon}}}{\lambda_{\text{electron}}} = \frac{\frac{hc}{E}}{\frac{h}{\sqrt{2mE}}}$$

Simplifying this expression:

$$\frac{\lambda_{\text{photon}}}{\lambda_{\text{electron}}} = \frac{hc}{E} \times \frac{\sqrt{2mE}}{h}$$

Cancel out h:

$$= \frac{c}{E} \times \sqrt{2mE}$$

Simplify further:

$$= c\sqrt{\frac{2m}{E}}$$

Hence, the correct option is **Option D**: $c\sqrt{\frac{2m}{E}}$.

Question61

When photons of energy hv fall on a photosensitive surface of work function E_0, photoelectrons of maximum energy k are emitted. If the frequency of radiation is doubled the maximum kinetic energy will be equal to (h = Planck's constant)

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Options:

A. k

B. 2 k

C. $k + E_0$

D. $k + h\nu$

Answer: D

Solution:

The photoelectric effect can be described by the equation:

$$K_{\text{max}} = h\nu - E_0$$

where:

K_{max} is the maximum kinetic energy of the emitted photoelectrons,

h is Planck's constant,

ν is the frequency of the incident photons,

E_0 is the work function of the photosensitive surface.

Initially, photons of energy $h\nu$ fall on the surface, yielding the maximum kinetic energy:

$$k = h\nu - E_0$$

If the frequency of the radiation is doubled, the frequency becomes 2ν. The new maximum kinetic energy K'_{max} is:

$$K'_{\text{max}} = h(2\nu) - E_0 = 2h\nu - E_0$$

Substitute the expression for k from the first equation:

$$2h\nu - E_0 = (h\nu - E_0) + h\nu = k + h\nu$$

Therefore, the maximum kinetic energy when the frequency is doubled would be:

Option D: $k + h\nu$

Question62

The number of photoelectrons emitted for light of frequency v (higher than the threshold frequency (v_0) is proportional to

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Options:

A. threshold frequency (v_0)

B. intensity of light (I)

C. frequency of light (v)

D. work function (ϕ_0)

Answer: B

Solution:

Intensity $\propto$ No. of photons

$\therefore$ Intensity $\propto$ No. of photoelectrons

Question63

The stopping potential for a photelectric emission process is 10 V . The maximum kinetic energy of the electrons ejected in the process is [Charge on electron $e = 1.6 \times 10^{-19}C$]

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Options:

A. 3.2×10^{-19} J

B. 1.6×10^{-19} J

C. 1.6×10^{-18} J

D. 0 J

Answer: C

Solution:

Maximum kinetic energy is given by,

(K.E.)$_{\max}$ = eV$_s$
(K.E.)$_{\max}$ = $\left(1.6 \times 10^{-19}\right) \times 10$ ...(given, V$_s$ = 10 V)

$\therefore$ (K.E.)$_{\max}$ = 1.6×10^{-18} J

Question64

When a metallic surface is illuminated with a radiation of wavelength ' λ ', the stopping potential is ' V '. If the same surface is illuminated with radiation of wavelength ' 3λ ', the stopping potential is ' $\left(\frac{V}{6}\right)$ '. The threshold wavelength for the surface is

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Options:

A. 3λ

B. 4λ

C. 5λ

D. 6λ

Answer: C

Solution:

From Einstein's equation,

$hv = eV_0 + hv_0$

$\therefore \quad \dfrac{hc}{\lambda} - \dfrac{hc}{\lambda_0} = e\,V_0$

case (i) $\lambda = \lambda; V_0 = V$

$\dfrac{hc}{\lambda} - \dfrac{hc}{\lambda_0} = eV \quad ... (i)$

case (ii) $\lambda = 3\lambda; V_0 = \dfrac{V}{6}$

$\dfrac{hc}{3\lambda} - \dfrac{hc}{\lambda_0} = \dfrac{eV}{6} \quad ... (ii)$

$\therefore \quad \dfrac{\left(\dfrac{hc}{\lambda} - \dfrac{hc}{\lambda_0}\right)}{\left(\dfrac{hc}{3\lambda} - \dfrac{hc}{\lambda_0}\right)} = 6$

$\therefore \quad \dfrac{1}{\lambda} - \dfrac{1}{\lambda_0} = 6\left(\dfrac{1}{3\lambda} - \dfrac{1}{\lambda_0}\right)$

$\therefore \quad \dfrac{1}{\lambda} - \dfrac{1}{\lambda_0} = \dfrac{2}{\lambda} - \dfrac{6}{\lambda_0}$

$\therefore \quad \dfrac{-1}{\lambda_0} + \dfrac{6}{\lambda_0} = \dfrac{2}{\lambda} - \dfrac{1}{\lambda}$

$\therefore \quad \dfrac{5}{\lambda_0} = \dfrac{1}{\lambda} \Rightarrow \lambda_0 = 5\lambda$

Question65

The work function of metal ' A ' and ' B ' are in the ratio $1 : 2$. If light of frequency ' f ' and ' $2f$ ' is incident on surface ' A ' and ' B ' respectively, then the ratio of kinetic energies of emitted photo electrons is

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Options:

A. 1 : 1

B. 1 : 2

C. 1 : 3

D. 1 : 4

Solution:

For A, $E_{A_{max}} = h\nu - \phi_A$
For B, $E_{B_{max}} = h(2\nu) - \phi_B$

$$\frac{E_{A_{max}}}{E_{B_{max}}} = \frac{h\nu - \phi_A}{2h\nu - \phi_B}$$

As $\dfrac{\phi_A}{\phi_B} = \dfrac{1}{2} \Rightarrow \phi_B = 2\phi_A$

$$\therefore \quad \frac{E_{A_{max}}}{E_{B_{max}}} = \frac{\frac{h\nu - \phi_A}{\phi_A}}{\frac{2h\nu - \phi_B}{\phi_A}} = \frac{\frac{h\nu}{\phi_A} - 1}{\frac{2h\nu}{\phi_A} - 2}$$

$$= \frac{h\nu - \phi_A}{\phi_A} \times \frac{\phi_A}{2(h\nu - \phi_A)} = \frac{1}{2}$$

Question66

When radiation of wavelength 'λ' is incident on a metallic surface, the stopping potential is 4.8 V. If the surface is illuminated with radiation of double the wavelength then the stopping potential becomes 1.6 V. The threshold wavelength for the surface is

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Options:

A. 2λ

B. 4λ

C. 6λ

D. 8λ

Solution:

Stopping potential:

$$eV_0 = h\nu - \phi_0$$

$$eV_0 = \frac{hc}{\lambda} - \phi_0$$

For first case: $e(4.8) = \frac{hc}{\lambda} - \phi_0$ ..... (i)

For Second case: $e(1.6) = \frac{hc}{2\lambda} - \phi_0$ ..... (ii)

Dividing equation (i) by equation (ii),

$$3\left(\frac{hc}{2\lambda} - \phi_0\right) = \frac{hc}{\lambda} - \phi_0$$

$$\therefore \quad \frac{3hc}{2\lambda} - 3\phi_0 = \frac{hc}{\lambda} - \phi_0$$

$$\frac{hc}{2\lambda} = 2\phi_0$$

$$\frac{hc}{4\lambda} = \phi_0$$

$\therefore$ Threshold wavelength is 4λ.

Question67

The de-Broglie wavelength (λ) of a particle is related to its kinetic energy (E) as

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Options:

A. $\lambda \propto E$

B. $\lambda \propto E^{-1}$

C. $\lambda \propto E^{\frac{1}{2}}$

D. $\lambda \propto E^{-\frac{1}{2}}$

Answer: D

Solution:

De-Broglie wavelength, $\lambda = \frac{h}{\sqrt{2mE}}$

$\therefore \quad \lambda \propto E^{-\frac{1}{2}}$

Question68

Dual nature of light is exhibited by

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Options:

A. diffraction as well as photoelectric effect

B. diffraction as well as reflection

C. refraction as well as interference

D. photoelectric effect

Answer: A

Solution:

Both diffraction and photoelectric effect can be explained by the help of wave nature and particle nature of light.

Refraction and reflection is explained by the help of wave nature only.

Question69

When radiations of wavelength λ is incident on a metallic surface the stopping potential required is 4.8 V. If same surface is illuminated with radiations of double the wavelength, then required stopping potential becomes 1.6 V, then the value of threshold wavelength for the surface is

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Options:

A. 2λ

B. 4λ

C. 6λ

D. 8λ

Answer: B

Solution:

From Einstein's photoelectric equation,

$$\text{KE}_{\max} = hv - hv_0$$
$$\text{or} \quad eV = hv - hv_0$$
$$\Rightarrow \quad eV = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

Here, V is stopping potential and λ is the incident wavelength, whereas λ_0 its threshold wavelength.

For case 1 $e(4.8) = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$ ..... (i)

For case 2 $e(1.6) = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0}$ ..... (ii)

From Eqs. (i) and (ii), we get

$$e \times (3.2) = \frac{hc}{2\lambda}$$
$$\Rightarrow \quad e(1.6) = \frac{hc}{4\lambda} \quad .... \text{(iii)}$$

Putting the Eq. (iii) in Eq. (ii), we get

$$\Rightarrow \quad \frac{hc}{4\lambda} = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0}$$
$$\Rightarrow \quad \frac{hc}{\lambda_0} = \frac{hc}{2\lambda} - \frac{hc}{4\lambda}$$
$$\Rightarrow \quad \frac{hc}{\lambda_0} = \frac{hc}{4\lambda}$$
$$\Rightarrow \quad \lambda_0 = 4\lambda$$

Question70

When a light of wavelength 300 nm fall on a photoelectric emitter, photo electrons are emitted. For another emitter light of wavelength 600 nm is just sufficient for liberating photoelectrons. The ratio of the work function of the two emitters is

Options:

A. 1 : 2

B. 2 : 1

C. 4 : 1

D. 1 : 4

Answer: B

Solution:

Work function $\phi_0 = \frac{hc}{\lambda_0}$

$\therefore \quad \phi_0 \propto \dfrac{1}{\lambda_0}$

$\qquad \dfrac{\phi_{01}}{\phi_{0_2}} = \dfrac{\lambda_{0_2}}{\lambda_{0_1}} = \dfrac{600}{300} = \dfrac{2}{1}$

Question71

Light of frequency 1.5 times the threshold frequency is incident on photosensitive material. If the frequency is halved and intensity is doubled, the photocurrent becomes

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Options:

A. quadrupled

B. double

C. half

D. zero

Answer: D

Solution:

If threshold frequency is ν_0, then light frequency becomes $1.5 \, \nu_0$.

If we make it half it becomes $0.75 \, \nu_0$, which is smaller than threshold frequency, therefore photoelectric current is zero.

Question72

Graph shows the variation of de-Broglie wavelength (λ) versus $\dfrac{1}{\sqrt{V}}$ where 'V' is the accelerating potential for four particles A, B, C, D carrying same charge but of masses m_1, m_2, m_3, m_4. Which on represents a particle of largest mass?
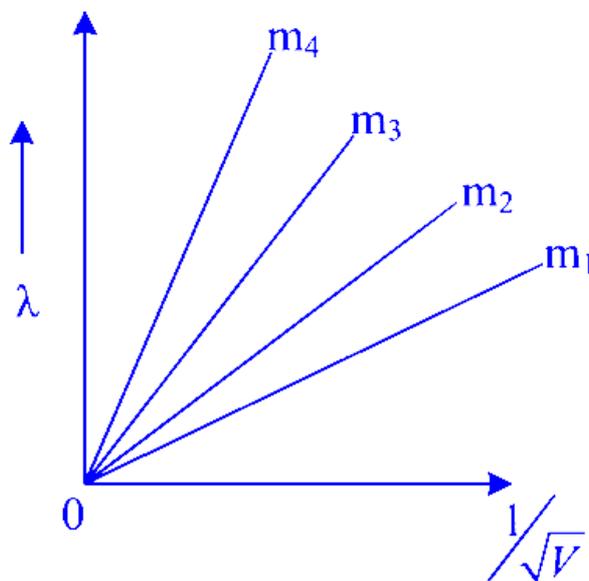
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Options:

A. m_1

B. m^2

C. m^3

D. m^4

Answer: A

Solution:

de Broglie wavelength $\lambda = \frac{h}{p}$

$\therefore \lambda = \dfrac{h}{\sqrt{2mqv}}$

$\therefore \lambda\sqrt{v} = \dfrac{h}{\sqrt{2mq}} \Rightarrow \dfrac{\lambda}{\left(\frac{1}{\sqrt{v}}\right)} = \dfrac{1}{\sqrt{2mq}}$

$\therefore$ Slope of the graph $= \dfrac{1}{\sqrt{2mq}}$

The slope will be maximum for minimum mass,

$\therefore$ m_4 is minimum and m_1 will be minimum.

Question73

When an electron is accelerated through a potential 'V', the de-Broglie wavelength associated with it is '4λ'. When the accelerating potential is increased to 4 V, its wavelength will be

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Options:

A. $\frac{\lambda}{4}$

B. $\frac{\lambda}{2}$

C. λ

D. 2λ

Solution:

The de Broglie wavelength (λ) of a particle is given by the formula:

$$\lambda = \frac{h}{\sqrt{2meV}}$$

where:

- h is the Planck's constant,
- m is the mass of the electron,
- e is the charge of the electron, and
- V is the accelerating potential.

When the electron is accelerated through a potential V, the wavelength is given by:

$$\lambda_1 = \frac{h}{\sqrt{2meV}}$$

And the given condition states that this wavelength is 4λ.

When the accelerating potential is increased to $4V$, the new wavelength (λ_2) can be calculated as:

$$\lambda_2 = \frac{h}{\sqrt{2me(4V)}}$$

Let's simplify λ_2:

$$\lambda_2 = \frac{h}{\sqrt{8meV}} = \frac{h}{2\sqrt{2meV}} = \frac{1}{2} \cdot \frac{h}{\sqrt{2meV}}$$

So, $\lambda_2 = \frac{1}{2}\lambda_1 = \frac{1}{2} \cdot 4\lambda = 2\lambda$.

Hence, the answer is Option D: 2λ.

Question74

Radiations of two photons having energies twice and five times the work function of metal are incident successively on metal surface. The ratio of the maximum velocity of photo electrons emitted in the two cases will be

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Options:

A. 1 : 1

B. 1 : 2

C. 1 : 3

D. 1 : 4

Answer: B

Solution:

To determine the ratio of the maximum velocities of photoelectrons emitted due to the incident photons, we can apply the photoelectric equation given by Einstein. The kinetic energy (KE) of the emitted photoelectrons can be found by the equation:

$KE = hf - \phi$

where hf is the energy of the incident photon, and ϕ is the work function of the metal.

Since we know the energies of the photons are in multiples of the work function (ϕ): the first photon has an energy of 2ϕ and the second has an energy of 5ϕ, we can substitute these into the equation above to find the kinetic energies of the emitted photoelectrons in each case.

For the first photon:

$KE_1 = 2\phi - \phi = \phi$

For the second photon:

$KE_2 = 5\phi - \phi = 4\phi$

The kinetic energy of a photoelectron is also given by the equation:

$KE = \frac{1}{2}mv^2$

where m is the mass of the electron, and v is the velocity of the photoelectron. Therefore, we can equate the expressions for kinetic energy derived from the photoelectric effect to this kinetic energy formula to compare the velocities.

For the first photon:

$\phi = \frac{1}{2}mv_1^2$

For the second photon:

$4\phi = \frac{1}{2}mv_2^2$

To find the ratio $v_1 : v_2$, we solve for v_1 and v_2 and take the ratio. From $KE = \frac{1}{2}mv^2$, we get $v = \sqrt{\frac{2KE}{m}}$. Therefore, the velocities are:

$v_1 = \sqrt{\frac{2\phi}{m}}$

$$v_2 = \sqrt{\frac{2 \cdot 4\phi}{m}} = \sqrt{4}\sqrt{\frac{2\phi}{m}} = 2\sqrt{\frac{2\phi}{m}}$$

So, the ratio of v_1 to v_2 is $\frac{\sqrt{\frac{2\phi}{m}}}{2\sqrt{\frac{2\phi}{m}}} = \frac{1}{2}$.

Hence, the correct option is **Option B: 1 : 2**.

Question75

When light of wavelength λ is incident on a photosensitive surface the stopping potential is 'V'. When light of wavelength 3λ is incident on same surface the stopping potential is $\frac{V}{6}$. Then the threshold wavelength for the surface is

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Options:

A. 2λ

B. 3λ

C. 4λ

D. 5λ

Answer: D

Solution:

$$\lambda_1 = \lambda, (V_0)_1 = V$$
$$\lambda_2 = 3\lambda, (V_0)_2 = \frac{V}{6}$$

Photo electric equation is given by

$$eV_0 = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) \dots \text{ (i)}$$

In first case,

$$eV = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

For second case,

$$\frac{eV}{6} = hc\left(\frac{1}{3\lambda} - \frac{1}{\lambda_0}\right) \quad \ldots\ldots \text{(ii)}$$

Dividing equation (i) by equation (ii),

$$6 = \frac{\frac{1}{\lambda} - \frac{1}{\lambda_0}}{\frac{1}{3\lambda} - \frac{1}{\lambda_0}} = \frac{3\lambda_0 - \lambda}{\lambda_0 - 3\lambda}$$

$$\therefore \quad \lambda_0 = 5\lambda$$

Question76

When a metallic surface is illuminated with radiation of wavelength 'λ', the stopping potential is 'V'. If the same surface is illuminated with radiation of wavelength '2λ', the stopping potential is '$\left(\frac{V}{4}\right)$'. The threshold wavelength for the metallic surface is

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Options:

A. $\frac{5}{2}\lambda$

B. 3λ

C. 4λ

D. 5λ

Answer: B

Solution:

For stopping potential V, $eV = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$

For stopping potential $\frac{V}{4}$, $\frac{eV}{4} = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0}$

Taking the ratio, we get

$$4 = \frac{\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)}{\frac{1}{2\lambda} - \frac{1}{\lambda_0}}$$

$$4\left(\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right) = \frac{1}{\lambda} - \frac{1}{\lambda_0}$$

$$\left(\frac{2}{\lambda} - \frac{4}{\lambda_0}\right) = \frac{1}{\lambda} - \frac{1}{\lambda_0}$$

$$\left(\frac{2}{\lambda} - \frac{1}{\lambda}\right) = -\frac{1}{\lambda_0} + \frac{4}{\lambda_0}$$

$$\left(\frac{1}{\lambda}\right) = \frac{3}{\lambda_0}$$

$$\therefore \quad \lambda_0 = 3\lambda$$

Question77

A metal surface of work function $1 \cdot 13$ eV is irradiated with light of wavelength 310 nm. The retarding potential required to stop the escape of photoelectrons is [Take $\frac{hc}{e} = 1240 \times 10^{-9}$ SI units]

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Options:

A. 1.13 V

B. 2.87 V

C. 3.97 V

D. 4.23 V

Answer: B

Solution:

Energy of incident light:

$$E = \frac{hc}{e\lambda}$$
$$= \frac{1240 \times 10^{-9}}{310 \times 10^{-9}}$$
$$= 4 \text{ ev}$$

Stopping potential $V_0 = \frac{hc}{e\lambda} - \frac{\phi_0}{e}$

$V_0 = 4 - 1.13 = 2.87 \text{ V}$

Question78

The maximum kinetic energies of photoelectrons emitted are K_1 and K_2 when lights of wavelengths λ_1 and λ_2 are incident on a metallic surface. If $\lambda_1 = 3\lambda_2$ then

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Options:

A. $K_1 = \frac{K_2}{3}$

B. $K_1 < \frac{K_2}{3}$

C. $K_1 = 3K_2$

D. $3K_1 = 2K_2$

Answer: B

Solution:

Kinetic energy of the photoelectrons

$K = \frac{hc}{\lambda} - \phi$

$\therefore$ For wavelength λ_1,

$K_1 = \frac{hc}{\lambda_1} - \phi$ ..... (i)

$\therefore$ For wavelength λ_1,

$K_2 = \frac{hc}{\lambda_2} - \phi$ ..... (ii)

Subtracting equation (i) from equation (ii),

$$K_2 - K_1 = \frac{hc}{\lambda_2} - \phi - \frac{hc}{\lambda_1} + \phi$$

$$K_2 - K_1 = \frac{hc}{\lambda_2} - \frac{hc}{3\lambda_2}$$

$$K_2 - K_1 = \frac{2}{3}\frac{hc}{\lambda_2}$$

$$\frac{hc}{\lambda_2} = \frac{3}{2}(K_2 - K_1) \quad ..... \text{(iii)}$$

Substituting equation (iii) in equation (ii),

$$K_2 = \tfrac{3}{2}(K_2 - K_1) - \phi$$

$$2K_2 = 3K_2 - 3K_1 - 2\phi$$
$$K_2 - 3K_1 = 2\phi$$
As, $\phi > 0$
$$K_2 - 3K_1 > 0$$
$$K_1 < \frac{K_2}{3}$$

Question79

If the potential difference used to accelerate electrons is doubled, by what factor does the de-Broglie wavelength associated with electrons change?

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Options:

A. Wavelength in increased to $\frac{1}{\sqrt{2}}$ times.

B. Wavelength in increased to $\frac{1}{2}$ times.

C. Wavelength in decreased to $\frac{1}{\sqrt{2}}$ times.

D. Wavelength in decreased to $\frac{1}{2}$ times.

Answer: C

Solution:

From $\lambda = \dfrac{h}{\sqrt{2mqV}}$,

$\lambda \propto \dfrac{1}{\sqrt{V}}$

If potential difference is doubled, $\lambda \propto \dfrac{1}{\sqrt{2\,V}}$

$\therefore \quad \lambda$ is decreased by $\dfrac{1}{\sqrt{2}}$ times.

Question80

The maximum kinetic energy of the photoelectrons varies

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Options:

A. inversely with the intensity of incident radiation and is independent of its frequency.

B. inversely with the frequency of incident radiation and is independent on its intensity.

C. linearly with the frequency of incident radiation and depends on its intensity

D. linearly with the frequency of incident radiation and is independent of its intensity.

Answer: D

Solution:

Answer: **(D) linearly with the frequency of incident radiation and is independent of its intensity**

According to Einstein's photoelectric equation, the maximum kinetic energy (KE_{max}) of an emitted photoelectron is given by $KE_{max} = hf - \Phi$, where h is Planck's constant, f

is the frequency of the incident radiation, and **Φ** is the work function of the material.

- The equation shows that KE_{max} has a linear relationship with the frequency (f) of the incident radiation.
- The work function (**Φ**) is a characteristic of the material and is independent of the intensity of the incident radiation.
- Therefore, the maximum kinetic energy of the photoelectrons varies linearly with the frequency of incident radiation and is independent of its intensity.

Question81

An electron accelerated through a potential difference 'V_1' has a de-Broglie wavelength 'λ'. When the potential is changed to 'V_2' its de-Broglie wavelength increases by 50%. The value of $\left(\frac{V_1}{V_2} \right)$ is

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Options:

A. 3 : 1

B. 9 : 4

C. 3 : 2

D. 4 : 1

Answer: B

Solution:

For electron, de Broglie wavelength, $\lambda = \frac{1.228}{\sqrt{V}}$

Given: $\lambda_2 = \lambda_1 + 0.5\lambda_1 = 1.5\lambda_1$

$$\therefore \quad \frac{\lambda_2}{\lambda_1} = \sqrt{\frac{V_1}{V_2}}$$

$$\Rightarrow \frac{V_1}{V_2} = \left(\frac{\lambda_2}{\lambda_1}\right)^2 = \left(\frac{1.5\lambda_1}{\lambda_1}\right)^2 = \left(\frac{3}{2}\right)^2 = \frac{9}{4}$$

Question82

Maximum kinetic energy of photon is 'E' when wavelength of incident radiation is 'λ'. If wavelength of incident radiations is reduced to $\frac{\lambda}{3}$ then energy of photon becomes four times. Then work function of the metal is

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Options:

A. $\frac{3hc}{\lambda}$

B. $\frac{hc}{3\lambda}$

C. $\frac{hc}{\lambda}$

D. $\frac{hc}{2\lambda}$

Answer: B

Solution:

$E = \frac{hc}{\lambda} - \phi_0$ .... (i)

Given: $\lambda = \frac{\lambda}{3}$ and $E = 4E$

$4E = \dfrac{hc}{\lambda/3} - \phi_0$ ..... (ii)

$= \dfrac{3hc}{\lambda} - \phi_0$

$4\left(\dfrac{hc}{\lambda} - \phi_0\right) = \dfrac{3hc}{\lambda} - \phi_0$ .....(From (i))

$\dfrac{4hc}{\lambda} - 4\phi_0 = \dfrac{3hc}{\lambda} - \phi_0$

$$\frac{hc}{\lambda} = 3\phi_0$$

$$\phi_0 = \frac{hc}{3\lambda}$$

Question83

When photons of energies twice and thrice the work function of a metal are incident on the metal surface one after other, the maximum velocities of the photoelectrons emitted in the two cases are v_1 and v_2 respectively. The ratio $v_1 : v_2$ is

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Options:

A. $\sqrt{2} : 1$

B. $\sqrt{3} : 1$

C. $\sqrt{3} : \sqrt{2}$

D. $1 : \sqrt{2}$

Answer: D

Solution:

$K.E_{\max} = hv - \phi_0$

Given,

$E_1 = 2\phi_0$ and $E_2 = 3\phi_0$

$\Rightarrow \quad K \cdot E_1 = 2\phi_0 - \phi_0 = \phi_0$

$\Rightarrow \quad K \cdot E_2 = 3\phi_0 - \phi_0 = 2\phi_0$

but, $K \cdot E_1 = \frac{1}{2}mv_1^2$ and $K \cdot E_2 = \frac{1}{2}m_2^2$

$\therefore \quad \frac{K \cdot E_1}{K \cdot E_2} = \frac{v_1^2}{v_2^2} = \frac{1}{2}$

$\therefore \quad \frac{v_1}{v_2} = \frac{1}{\sqrt{2}}$

Question84

When a certain metal surface is illuminated with light of frequency v, the stopping potential for photoelectric current is V_0. When the same surface is illuminated by light of frequency $\frac{v}{2}$, the stopping potential is $\frac{V_0}{4}$, the threshold frequency of photoelectric emission is

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Options:

A. $\frac{v}{6}$

B. $\frac{v}{3}$

C. $\frac{2v}{3}$

D. $\frac{4v}{3}$

Answer: B

Solution:

$eV_0 = hv - hv_0$ ..... (i)

$\dfrac{eV_0}{4} = \dfrac{hv}{2} - hvv_0$ ..... (ii)

Dividing equation (i) by equation (ii),

$4 = \dfrac{v - v_0}{\frac{v}{2} - v_0}$

∴ $2v - 4v_0 = v - v_0$

∴ $3v_0 = v$

∴ $v_0 = \frac{v}{3}$

Question85

From a metallic surface photoelectric emission is observed for frequencies v_1 and v_2 $(v_1 > v_2)$ of the incident light. The maximum values of the kinetic energy of the photoelectrons emitted in the two cases are in the ratio $1 : x$. Hence the threshold frequency of the metallic surface is

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Options:

A. $\frac{v_1 - v_2}{x}$

B. $\frac{v_1 - v_2}{x - 1}$

C. $\frac{x v_1 - v_2}{x - 1}$

D. $\frac{x v_2 - v_1}{x - 1}$

Answer: C

Solution:

Using Einstein's photoelectric equation,

$$E_k = hv - \phi_0$$
$$E_k = hv - hv_0$$

$\therefore$ $E_{K_1} = h(v_1 - v_0)$ and $E_{K_2} = h(v_2 - v_0)$

     Given $\frac{E_{K_1}}{E_{K_2}} = \frac{1}{x}$

$\Rightarrow \frac{v_1 - v_0}{v_2 - v_0} = \frac{1}{x}$

$(v_1 - v_0)x = v_2 - v_0$

$v_1 x - v_0 x = v_2 - v_0$

$\therefore$ $v_1 x - v_2 = v_0 x - v_0$

$v_1 x - v_2 = v_0(x - 1)$

$\therefore$ $v_0 = \frac{v_1 x - v_2}{x - 1}$

Question86

If the kinetic energy of a free electron doubles, it's de Broglie wavelength (λ) changes by a factor

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Options:

A. $\frac{1}{\sqrt{2}}$

B. $\frac{1}{2}$

C. $\sqrt{2}$

D. 2

Answer: A

Solution:

$\lambda = \frac{h}{\sqrt{2mE}}$ where E is the K.E.

$$\therefore \lambda \propto \frac{1}{\sqrt{E}} \qquad \therefore \frac{\lambda_2}{\lambda_1} = \sqrt{\frac{E_1}{E_2}} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$$

$$\therefore \lambda_2 = \frac{\lambda_1}{\sqrt{2}}$$

Thus λ charges by a factor $\frac{1}{\sqrt{2}}$

Question87

A light of wavelength 'λ' and intensity 'I' falls on photosensitive material. If 'N' photo electrons are emitted, each with kinetic energy 'E', then

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Options:

A. $E \propto I, N \propto \lambda$

B. $E \propto I, N \propto I$

C. $E \propto I, N \propto \frac{1}{\lambda}$

D. $E \propto \frac{1}{\lambda}, N \propto I$

Answer: D

Solution:

To understand the relationship between kinetic energy (E) of photoelectrons, wavelength (λ) of incident light, and intensity (I) of the light in the context of the photoelectric effect, we need to review the basics of the photoelectric effect. The photoelectric effect is governed by Einstein's equation:

$$E_{\text{photon}} = h\nu = h\frac{c}{\lambda}$$

where h is Planck's constant, ν is the frequency of the incident light, and c is the speed of light.

According to the photoelectric effect:

$$E = E_{\text{photon}} - \phi = h\nu - \phi = h\frac{c}{\lambda} - \phi$$

Here, ϕ is the work function of the material.

From the above equation, it's clear that the kinetic energy E of the emitted photoelectrons is inversely proportional to the wavelength λ of the incident light and not dependent on the intensity (I) of the light. Thus:

$$E \propto \frac{1}{\lambda}$$

Additionally, the number of photoelectrons (N) emitted is directly proportional to the intensity of the incident light. This is because the intensity of the light corresponds to the number of photons hitting the surface per unit time. Therefore:

$$N \propto I$$

Combining these relationships, the correct option is:

Option D: $E \propto \frac{1}{\lambda}, N \propto I$

Question88

In a photoelectric experiment, a graph of maximum kinetic energy (KE_{max}) against the frequency of incident radiation (v) is plotted. If A and B are the intercepts on the X and Y axis respectively then the Planck's constant is given by
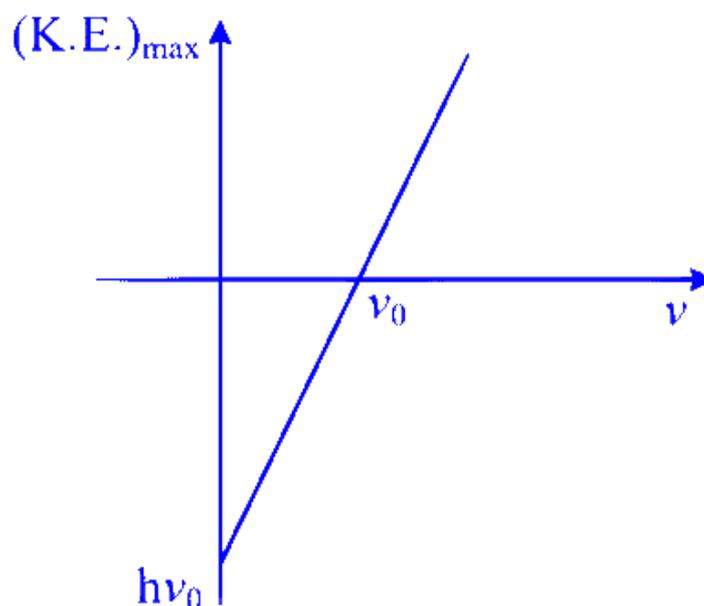
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Options:

A. $A + B$

B. $\frac{B}{A'}$

C. $A \times B$

D. $\frac{A}{B}$

Answer: B

Solution:

Kinetic energy is given by

$(K.E.)_{max} = hv - hv_0$

Comparing $y = mx + c$

We get x-intercept when

$(K.E.)_{max} = 0$, i.e. $h\nu - h\nu_0 = 0$

or $\nu = \nu_0 = A$

We get y-intercept when $\nu = 0$

$\therefore (K.E.)_{max} = -h\nu_0 = B$

$\therefore \left|\dfrac{B}{A}\right| = \dfrac{h\nu_0}{\nu_0} = h$

Question89

A photon has wavelength 3 nm, then its momentum and energy respectively will be $[h = 6.63 \times 10^{-34} Js, c = $ velocity of light $= 3 \times 10^8$ m/s$]$

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Options:

A. 2.21×10^{-43} kg ms^{-1}; 6.63×10^{-34} J

B. 2.21×10^{-34} kg ms^{-1}; 6.63×10^{-25} J

C. 2.21×10^{-25} kg ms^{-1}; 6.63×10^{-17} J

D. 2.21×10^{-16} kg ms^{-1}; 6.63×10^{-19} J

Answer: C

Solution:

Momentum $p = \dfrac{h}{\lambda} = \dfrac{6.63 \times 10^{-34}}{3 \times 10^{-9}} = 2.21 \times 10^{-25}$ kg ms^{-1}

Energy

$E = \dfrac{hc}{\lambda} = pc = 2.21 \times 10^{-25} \times 3 \times 10^8$

$\quad = 6.63 \times 10^{-17}$ J

Question90

In photoelectric experiment keeping the frequency of incident radiation and accelerating potential fixed, if the intensity of incident light is increased,

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Options:

A. photoelectric current decreases

B. kinetic energy of emitted photoelectrons decreases

C. photoelectric current increases

D. kinetic energy of emitted photoelectrons increases

Answer: C

Solution:

Photoelectric current is proportional to the intensity of the incident light.

Question91

de-Broglie wavelength associated with an electron accelerated through a potential difference 'V' is 'λ'. When the accelerating potential is increased to '4 V', de-Broglie wavelength.

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Options:

A. reduces to half

B. remains the same

C. reduces to $(1/4)^{\text{th}}$

D. increases by 25%

Answer: A

Solution:

The de Broglie wavelength associated with an electron is given by the formula:

$$\lambda = \frac{h}{p}$$

where h is Planck's constant and p is the momentum of the electron.

For an electron accelerated through a potential difference V, the energy acquired by the electron is given by:

$$eV = \frac{1}{2}mv^2$$

where e is the charge of the electron, m is the mass of the electron, and v is the velocity of the electron.

From the above equation, we can express the momentum p in terms of the voltage V:

$$p = \sqrt{2meV}$$

Substituting this into the de Broglie wavelength equation, we get:

$$\lambda = \frac{h}{\sqrt{2meV}}$$

This shows that the de Broglie wavelength is inversely proportional to the square root of the accelerating potential:

$$\lambda \propto \frac{1}{\sqrt{V}}$$

Now, when the accelerating potential is increased to $4V$, the new wavelength λ' will be:

$$\lambda' = \frac{h}{\sqrt{2me(4V)}} = \frac{h}{2\sqrt{2meV}} = \frac{\lambda}{2}$$

So, the de Broglie wavelength reduces to half. Therefore, the correct answer is:

Option A: reduces to half

Question92

In photoelectric effect, the photo current

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Options:

A. does not depend on the frequency of photon but depends on intensity of incident light.

B. decreases with Increase in frequency of incident photon.

C. increases with increase in frequency of incident photon.

D. depends with on intensity of incident radiation and its frequency.

Answer: A

Solution:

The photoelectric effect is a phenomenon where electrons are ejected from the surface of a material when it is exposed to light of sufficient frequency. The photo current, which is the current produced due to these ejected electrons, has specific dependencies based on the properties of the incident light.

Option A states that the photo current does not depend on the frequency of the photon but depends on the intensity of incident light. This is generally correct. The intensity of the incident light increases the number of photons hitting the surface per unit time, which in turn increases the number of electrons being ejected, and thus increases the photo current. However, the

frequency of the photons determines whether electrons are ejected at all. There is a threshold frequency below which no electrons are ejected, regardless of the light intensity.

Option B states that photo current decreases with an increase in the frequency of the incident photon. This is incorrect. Increasing the frequency of the photon, provided it is above the threshold frequency, increases the energy of ejected electrons but does not decrease the photo current.

Option C states that photo current increases with an increase in the frequency of the incident photon. This is also incorrect in a general sense because the photo current is more influenced by the number of photons (intensity) rather than the energy (frequency) of individual photons. Above the threshold frequency, the photo current remains more or less constant as frequency increases.

Option D states that photo current depends on the intensity of incident radiation and its frequency. This is incorrect because the photo current specifically depends on the intensity of the incident light, provided the frequency is above the threshold frequency. The frequency mainly affects the kinetic energy of the ejected electrons, not the number of electrons ejected.

Therefore, the correct answer is:

Option A: does not depend on the frequency of photon but depends on intensity of incident light.

Question93

According to de-Broglie hypothesis if an electron of mass 'm' is accelerated by potential difference 'V', the associated wavelength is 'λ'. When a proton of mass 'M' is accelerated through potential difference 9 V, then the wavelength associated with it is

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Options:

A. $\frac{\lambda}{3} \sqrt{\frac{m}{M}}$

B. $\frac{3}{2} \sqrt{\frac{m}{M}}$

C. $\frac{\lambda}{3} \sqrt{\frac{M}{m}}$

D. $\frac{3}{\lambda} \sqrt{\frac{M}{m}}$

Answer: A

Solution:

$\lambda = \frac{h}{\sqrt{2mqV}}$

For electron and proton change q has same value. If λ' is the wavelength of the proton, then

$$\lambda' = \frac{h}{\sqrt{2Mq \times 9v}}$$

$$\therefore \frac{\lambda'}{\lambda} = \frac{1}{3}\sqrt{\frac{m}{M}}$$

Question94

When wavelength of incident radiation on the metal surface is reduced from 'λ_1' to 'λ_2', the kinetic energy of emitted photoelectrons is tripled. The work function of metal [$h = $ Plank's constant, $c = $ velocity of light]

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Options:

A. $\frac{hc}{2}\left[\frac{3\lambda_1 - \lambda_2}{\lambda_1 \lambda_2}\right]$

B. $\frac{hc}{2}\left[\frac{3\lambda_2 - \lambda_1}{\lambda_1 \lambda_2}\right]$

C. $hc\left[\frac{3\lambda_1 - \lambda_2}{\lambda_1 \lambda_2}\right]$

D. $hc\left[\frac{3\lambda_2 - \lambda_1}{\lambda_1 \lambda_2}\right]$

Answer: B

Solution:

Let K represent kinetic energy

$$\therefore \quad K_1 = \frac{hc}{\lambda_1} - W_0$$

and $K_2 = \dfrac{hc}{\lambda_2} - W_0$

$K_2 = 3 K_1$

$\therefore \quad \dfrac{hc}{\lambda_2} - W_0 = 3\dfrac{hc}{\lambda_1} - 3W_0$

$\therefore \quad 2W_0 = \dfrac{3hc}{\lambda_1} - \dfrac{hc}{\lambda_2}$

$\therefore \quad W_0 = \dfrac{hc}{2}\left(\dfrac{3\lambda_2 - \lambda_1}{\lambda_1\lambda_2}\right)$

Question95

An electron of mass 'm' and a photon have same energy 'E'. The ratio of de-Broglie wavelength of electron to the wavelength of photon is (c = velocity of light)

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Options:

A. $c\sqrt{\dfrac{E}{m}}$

B. $\dfrac{1}{c}\sqrt{\dfrac{2m}{g}}$

C. $\dfrac{1}{c}\sqrt{\dfrac{E}{2m}}$

D. $c\sqrt{\dfrac{m}{E}}$

Answer: C

Solution:

To determine the ratio of the de-Broglie wavelength of an electron to the wavelength of a photon when both have the same energy E, we need to understand their respective relations with energy and wavelength.

The de-Broglie wavelength λ_e of an electron is given by:

$$\lambda_e = \frac{h}{p}$$

where h is Planck's constant and p is the momentum of the electron. For an electron with non-relativistic energy, its kinetic energy E is related to its momentum by:

$$E = \frac{p^2}{2m}$$

Thus, we can solve for the momentum:

$$p = \sqrt{2mE}$$

Substituting this into the de-Broglie wavelength formula, we get:

$$\lambda_e = \frac{h}{\sqrt{2mE}}$$

Now, for a photon, its wavelength λ_γ is related to its energy by:

$$E = \frac{hc}{\lambda_\gamma}$$

Solving for the wavelength, we get:

$$\lambda_\gamma = \frac{hc}{E}$$

We need the ratio of the de-Broglie wavelength of the electron to the wavelength of the photon:

$$\frac{\lambda_e}{\lambda_\gamma} = \frac{\frac{h}{\sqrt{2mE}}}{\frac{hc}{E}}$$

Simplifying the expression, we get:

$$\frac{\lambda_e}{\lambda_\gamma} = \frac{1}{c}\sqrt{\frac{E}{2m}}$$

Thus, the correct answer is:

Option C: $\frac{1}{c}\sqrt{\frac{E}{2m}}$

Question96

When a photon enters glass from air, which one of the following quantity does not change?

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Options:

A. Energy

B. Velocity

C. Wavelength

D. Momentum

Answer: A

Solution:

Energy of the photon is given by

$E = h\nu$

The frequency of photon does not change hence the energy does not change.

Question97

The light of wavelength 'λ' is incident on the surface of metal of work function ϕ and emits the electron. The maximum velocity of electron emitted is [m = mass of electron and h = Planck's constant, c = velocity of light]

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Options:

A. $\left[\frac{2(hc-\lambda)}{m\lambda}\right]^{\frac{1}{2}}$

B. $\left[\frac{2(hc-\phi)\lambda}{mc}\right]$

C. $\left[\frac{2(hc-\lambda)}{m\lambda}\right]$

D. $\left[\frac{2(hc-\lambda\phi)}{m\lambda}\right]^{\frac{1}{2}}$

Answer: D

Solution:

We have $\frac{1}{2}mv^2_{\max} = \frac{hc}{\lambda} - \phi = \frac{hc-\phi\lambda}{\lambda}$

$\therefore \quad V^2_{\max} = \frac{2(hc-\phi\lambda)}{m\lambda}$

$\therefore \quad V_{\max} = \sqrt{\frac{2(hc-\phi\lambda)}{m\lambda}}$

Question98

Photons of energy 10 eV are incident on a photosensitive surface of threshold frequency 2×10^{15} Hz. The kinetic energy in eV of the photoelectrons emitted is

[Planck's constant $h = 6.63 \times 10^{34}$ Js]

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Options:

A. 8.29 eV

B. 6.5 eV

C. 4.2 eV

D. 1.71 eV

Answer: D

Solution:

First, let's recall that the kinetic energy (KE) of the ejected electrons can be found using the formula:

$KE = E - W = h\nu - h\nu_0$

where:

- KE is the kinetic energy of the ejected electrons,
- $E = h\nu$ is the energy of the incident photon,
- h is Planck's constant,
- ν is the frequency of the incident photon,
- $W = h\nu_0$ is the work function of the material, and
- ν_0 is the threshold frequency.

To find the kinetic energy in electron-volts (eV), we first need to calculate the energy of the incident photons and the work function using the provided values. The energy of the incident photon (E) is given to be 10 eV directly.

The work function (W), however, needs to be calculated. It is the energy corresponding to the threshold frequency (ν_0), so we can calculate it using:

$$W = h\nu_0$$

Given that $h = 6.63 \times 10^{-34}$ Js (or meter2 kg / s in SI units), and $\nu_0 = 2 \times 10^{15}$ Hz, let's calculate W. However, since our final answer is desired in electron-volts, we must remember that 1 eV $= 1.602 \times 10^{-19}$ J.

To calculate the work function in eV, we use:

$$W = h\nu_0 = (6.63 \times 10^{-34} \text{ Js}) \times (2 \times 10^{15} \text{ Hz})$$

$$W = 1.326 \times 10^{-18} \text{ J}$$

Convert W to eV:

$$W = \frac{1.326 \times 10^{-18} \text{ J}}{1.602 \times 10^{-19} \text{ eV/J}} = 8.29 \text{ eV}$$

Now, we can calculate the kinetic energy of the photoelectrons:

$$KE = E - W = 10 \text{ eV} - 8.29 \text{ eV}$$

$$KE = 1.71 \text{ eV}$$

Therefore, the kinetic energy of the photoelectrons emitted is **1.71 eV**, which corresponds to Option D.

Question99

When a light of wavelength 'λ' falls on the emitter of a photocells, maximum speed of emitted photoelectrons is 'V'. If the incident wavelength is changed to $\frac{2\lambda}{3}$, maximum speed of emitted photoelectrons will be

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Options:

A. less than $V(1.5)^{1/2}$

B. $\sqrt{V}$

C. grater than $V(1.5)^{\frac{1}{2}}$

D. V

Answer: C

Solution:

Here's a detailed explanation of the solution:

The photoelectric effect is governed by Einstein's photoelectric equation:

$h\nu = \phi + \frac{1}{2}mv^2$

where:

- h is Planck's constant
- ν is the frequency of the incident light
- ϕ is the work function of the metal (the minimum energy required to eject an electron)
- m is the mass of the electron
- v is the maximum speed of the emitted photoelectron

We can rewrite the equation in terms of wavelength using the relationship $c = \nu\lambda$ (where c is the speed of light):

$hc/\lambda = \phi + \frac{1}{2}mv^2$

Let's analyze the scenario:

Initially, with wavelength λ, the maximum speed is v. So we have:

$hc/\lambda = \phi + \frac{1}{2}mv^2$

Now, the wavelength is changed to $\frac{2\lambda}{3}$. Let's call the new maximum speed v'. The equation becomes:

$hc/(\frac{2\lambda}{3}) = \phi + \frac{1}{2}mv'^2$

Simplifying the second equation:

$\frac{3hc}{2\lambda} = \phi + \frac{1}{2}mv'^2$

Notice that the work function (ϕ) remains the same for the same metal. Subtracting the first equation from the second equation, we get:

$\frac{3hc}{2\lambda} - \frac{hc}{\lambda} = \frac{1}{2}mv'^2 - \frac{1}{2}mv^2$

Simplifying further:

$\frac{hc}{2\lambda} = \frac{1}{2}m(v'^2 - v^2)$

We can now see that the left-hand side of the equation has increased by a factor of 1.5. Therefore, the right-hand side must also increase by a factor of 1.5. This means:

$v'^2 - v^2 = 1.5v^2$

Solving for v':

$v'^2 = 2.5v^2$

$v' = \sqrt{2.5}v = \sqrt{1.5^2}v = 1.5v$

Therefore, the maximum speed of emitted photoelectrons will be greater than $v(1.5)^{\frac{1}{2}}$.

The correct answer is Option C: greater than $v(1.5)^{\frac{1}{2}}$

Question100

Kinetic energy of a proton is equal to energy 'E' of a photon. Let 'λ_1' be the de-Broglie wavelength of proton and 'λ_2' is the wavelength of photon. If $\frac{\lambda_1}{\lambda_2} \alpha E^n$, then the value of '$n$' is

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Options:

A. $\frac{1}{2}$

B. $\frac{1}{4}$

C. 2

D. 4

Answer: A

Solution:

To find the value of 'n', we need to analyze the expressions for the de-Broglie wavelength of the proton and the wavelength of the photon in terms of the energy 'E'.

The kinetic energy of the proton is given by:

$E_{\text{proton}} = \frac{1}{2}mv^2$

where m is the mass of the proton and v is its velocity.

The de-Broglie wavelength λ_1 of the proton is:

$\lambda_1 = \frac{h}{mv}$

Using the expression for kinetic energy, we can write:

$$E = \frac{1}{2}mv^2 \implies v = \sqrt{\frac{2E}{m}}$$

Substituting this into the expression for the de-Broglie wavelength:

$$\lambda_1 = \frac{h}{m\sqrt{\frac{2E}{m}}} = \frac{h}{\sqrt{2mE}}$$

Next, consider the energy of the photon:

$$E_{\text{photon}} = E = \frac{hc}{\lambda_2}$$

Solving for the wavelength λ_2 of the photon:

$$\lambda_2 = \frac{hc}{E}$$

Now we need to find the ratio $\frac{\lambda_1}{\lambda_2}$:

$$\frac{\lambda_1}{\lambda_2} = \frac{\frac{h}{\sqrt{2mE}}}{\frac{hc}{E}} = \frac{hE}{hc\sqrt{2mE}} = \frac{E}{c\sqrt{2mE}} = \frac{E^{\frac{1}{2}}}{c\sqrt{2m}}$$

From this expression, it is clear that:

$$\frac{\lambda_1}{\lambda_2} = \alpha E^{\frac{1}{2}}$$

where α is a constant involving other parameters like Planck's constant and mass of the proton.

Therefore, the value of 'n' is:

$$\boxed{\dfrac{1}{2}}$$

Question101

The wave number of the last line of the Balmer series in the hydrogen spectrum will be (Rydberg's cons $\tan t, R = \frac{10^7}{\text{m}}$)

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Options:

A. $16 \times 10^4 \text{ m}^{-1}$

B. $8 \times 10^5 \text{ m}^{-1}$

C. $36 \times 10^7 \text{ m}^{-1}$

D. $25 \times 10^5 \text{ m}^{-1}$

Answer: D

Solution:

The wave number of the last line of the Balmer series is given by

$\frac{1}{\lambda} = \frac{R}{4} = \frac{10^7}{4} = 25 \times 10^5 \text{ m}^{-1}$

Question102

Photoemission from metal surface takes place for frequencies 'v_1' and 'v_2' of incident rays $(v_1 > v_2)$. Maximum kinetic energy of photoelectrons emitted is in the ratio $1 : \text{K}$. The threshold frequency of metallic surface is

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Options:

A. $\frac{Kv_2 - v_1}{K - 1}$

B. $\frac{v_1 - v_2}{K - 1}$

C. $\frac{v_2 - v_1}{K}$

D. $\frac{Kv_1 - v_2}{K - 1}$

Answer: D

Solution:

(K.E.)$_1 = hv_1 - hv_0$ .....(1)
(K.E.)$_2 = hv_2 - hv_0$ .....(2)

Dividing Eq.(1) by Eq.(2) :

$\frac{(\text{K.E}_1)}{(\text{K.E})_2} = \frac{1}{k} = \frac{v_1 - v_0}{v_2 - v_0}$

Solving for v_0 we get :

$v_0 = \frac{kv_1 - v_2}{k-1}$

Question103

A proton and alpha particle are accelerated through the same potential difference. The ratio of the de-Broglie wavelength of proton to that of alpha particle will be (mass of alpha particle is four times mass of proton.)

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Options:

A. 1 : 2

B. $2\sqrt{2} : 1$

C. 1 : 1

D. 2 : 1

Answer: B

Solution:

De-Broglie wavelength is given by

$\lambda = \frac{h}{\sqrt{2mqv}}$

If λ_1 and λ_2 are de-Broglie wavelengths of proton and alpha particle then

$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2 q_2}{m_1 q_1}} = \sqrt{4 \times 2} = \sqrt{8} = 2\sqrt{2}$

Question104

Light of frequency two times the threshold frequency is incident on photosensitive material. If the incident frequency

is made $\left(\frac{1}{3}\right)^{\text{rd}}$ and intensity is doubled, then the photoelectric current will

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Options:

A. increase

B. decrease

C. be zero

D. be halved

Answer: C

Solution:

Initial frequency $v = 2v_0$

Final frequency $v' = \frac{2v_0}{3}$

v' is less than the threshold frequency v_0

Hence no photoelectrons will be emitted and photoelectric current will be zero.

Question105

On a photosensitive surface, if the intensity of incident radiation is increased, the stopping potential

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Options:

A. first increases and then decreases

B. decreases

C. increases

D. remains unchanged

Answer: D

Solution:

The kinetic energy of the photo electrons and hence the stopping potential does not depend on the intensity of light.

Question106

What is the additional energy that should be supplied to a moving electron to reduce its de Broglie wavelength from 1 nm **to** 0.5 nm **?**

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Options:

A. Four times its initial energy.

B. Five times its initial energy.

C. Two times its initial energy.

D. Three times its initial energy.

Answer: D

Solution:

$\lambda_1 = 1$ nm, $\lambda_2 = 0.5$ nm

$\therefore \lambda_2 = \frac{\lambda_1}{2}$

$\lambda = \frac{h}{p} \qquad \therefore P_2 = 2P_1$

Kinetic energy, $E = \frac{P^2}{2m}$

$$\therefore \frac{E_2}{E_1} = \left(\frac{P_2}{P_1}\right)^2 = (2)^2 = 4$$
$$\therefore E_2 = 4E_1$$
$$\therefore E_2 - E_1 = 3E_1$$

Question107

Photoelectrons are emitted when photons of energy 4.2 eV **are incident on a photosensitive metallic sphere of radius** 10 cm **and work function** 2.4 eV**. The number of photoelectrons emitted before the emission is stopped is**

$$\left[\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ SI unit; } e = 1.6 \times 10^{-19} C\right]$$

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Options:

A. 1.25×10^6

B. 1.25×10^2

C. 1.25×10^8

D. 1.25×10^4

Answer: C

Solution:

$\text{hv} = 4.2 \text{ eV}, \omega_0 = 2.4 \text{ eV}, (\text{KE})_{\max} = 4.2 - 2.4 = 1.8 \text{ eV}$

The electrons will not be able to escape from the surface when its potential becomes 1.8 V.

$$V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$$
$$\therefore 1.8 = 9 \times 10^9 \times \frac{q}{0.1}$$
$$\therefore q = 2 \times 10^{-8} C$$
$$\therefore ne = q$$
$$n = \frac{q}{e} = \frac{2 \times 10^{-11}}{1.8 \times 10^{-14}} = 1.25 \times 10^8$$

Question108

When light of wavelength 'λ' is incident on a photosensitive surface, photons of power 'P' are emitted. The number of photon 'n' emitted in time 't' is [h = Planck's constant, c = velocity of light in vacuum]

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Options:

A. $\frac{hc}{p\lambda t}$

B. $\frac{P\lambda}{htc}$

C. $\frac{P\lambda t}{hc}$

D. $\frac{hP}{\lambda tc}$

Answer: C

Solution:

Power $P = \frac{Energy}{t} = \frac{nhc}{\lambda t}$

$\therefore n = \frac{P\lambda t}{hC}$

Question109

When a photosensitive surface is irradiated by light of wavelengths 'λ_1' and 'λ_2', kinetic energies of emitted photoelectrons are 'E_1' and 'E_2' respectively. The work function of photosensitive surface is

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Options:

A. $\dfrac{(\lambda_1 E_1 - \lambda_2 E_2)}{(\lambda_2 - \lambda_1)}$

B. $\dfrac{(\lambda_1 E_1 + \lambda_2 E_2)}{(\lambda_2 - \lambda_1)}$

C. $\dfrac{(\lambda_1 E_2 - \lambda_2 E_1)}{(\lambda_2 - \lambda_1)}$

D. $\dfrac{(\lambda_1 E_2 + \lambda_2 E_1)}{(\lambda_2 - \lambda_1)}$

Answer: A

Solution:

$E_1 = \dfrac{hc}{\lambda_1} - W \quad \therefore E_1 \lambda_1 = hc - W\lambda_1$

$E_2 = \dfrac{hc}{\lambda_2} - W \quad \therefore hc = E_1 \lambda_1 + W\lambda_1$ ...... (i)

$\therefore E_2 \lambda_2 = hc - W_2 \quad \therefore hc = E_2 \lambda_2 + W\lambda_2$ .... (ii)
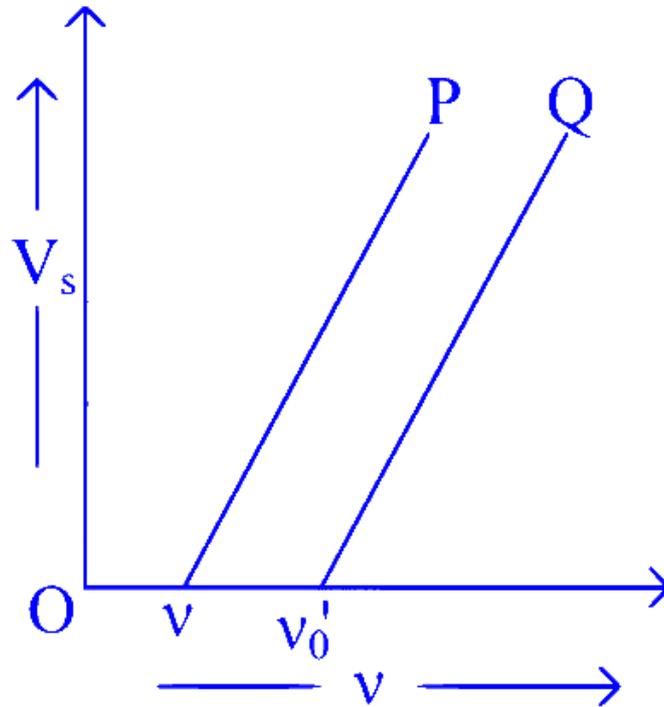
By Eq.(i) and (ii)

$E_1 \lambda_1 + W\lambda_1 = E_2 \lambda_2 + W\lambda_2$

$\therefore E_1 \lambda_1 - E_2 \lambda_2 = W(\lambda_2 - \lambda_1)$

$\therefore W = \dfrac{E_1 \lambda_1 - E_2 \lambda_2}{\lambda_2 - \lambda_1}$

Question110

The graph of stopping potential V_s against frequency v of incident radiation is plotted for two different metals P and Q as shown in the graph. ϕ_p and ϕ_Q are work-functions of P and Q respectively, then

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Options:

A. $\phi_P > \phi_Q$

B. $\phi_P < \phi_Q$

C. $\phi_P = \phi_Q$

D. $\nu_0' < \nu_0$

Answer: B

Solution:

The work-function of a surface is

$\phi = h\nu_0$

where, $h =$ Planck's constant

and $\nu_0 =$ threshold frequency.

From graph it is clear that,

$(\nu_0)_p < (\nu_0)_0$

$\therefore \quad \phi_p < \phi_Q$

Question111

If the maximum kinetic energy of emitted electrons in photoelectric effect is 3.2×10^{-19} J and the work-function for metal is 6.63×10^{-19} J, then stopping potential and threshold wavelength respectively are

[Planck's constant, $h = 6.63 \times 10^{34}$ J-s]

[Velocity of light, $c = 3 \times 10^8 \frac{\text{m}}{\text{s}}$]

[Charge on electron $= 1.6 \times 10^{-19}$ C]

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Options:

A. 4V, $6000\overset{o}{A}$

B. 3V, $4000\overset{o}{A}$

C. 2V, $3000\overset{o}{A}$

D. 1V, $1000\overset{o}{A}$

Answer: C

Solution:

The maximum kinetic energy of emitted photoelectron is

$K_{\text{max}} = eV_s$

where, $V_s =$ stopping potential.

$\Rightarrow \quad V_s = \frac{K_{\text{max}}}{\theta} = \frac{3.2 \times 10^{-19}}{1.6 \times 10^{-19}} = 2$ V

Also, the work-function of a metal is

$$\phi = \frac{1242}{\lambda_0(\text{ nm})}\text{eV}$$

$$\lambda_0 = \frac{1242 \times 1.6 \times 10^{-19}}{\phi} \text{ nm}$$

$$\Rightarrow \quad = \frac{1242 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-19}} \text{ nm}$$

$$\approx 3000 \overset{o}{A}$$

Question112

The light of wavelength λ incident on the surface of metal having work function ϕ emits the electrons. The maximum velocity of electrons emitted is [$c =$ velocity of light, $h =$ Planck's constant, $m =$ mass of electron]

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Options:

A. $\left[\frac{2(hv-\phi)\lambda}{mc}\right]$

B. $\left[\frac{2(hc-\lambda\phi)}{m\lambda}\right]^{1/2}$

C. $\left[\frac{2(hc-\lambda)}{m\lambda}\right]^{1/2}$
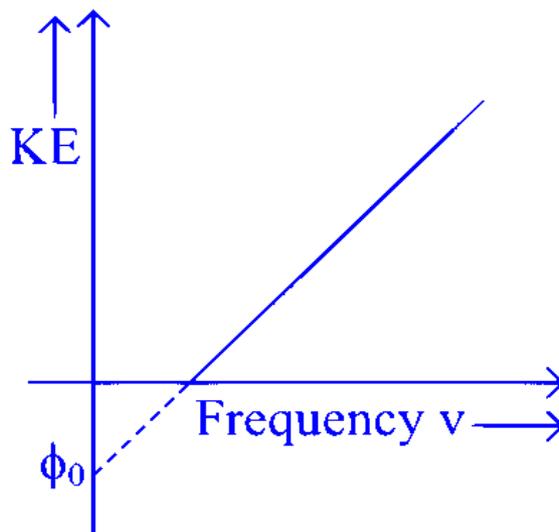
D. $\left[\frac{2(hc-\phi)}{m\lambda}\right]$

Answer: B

Solution:

photoelectric effect, the maximum kinetic energy possessed by the particle,

$$\text{KE}_{\max} = hv - \phi$$
$$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi \quad \left(\because v = \frac{c}{\lambda}\right)$$
$$\Rightarrow \quad v^2 = \frac{2(hc - \phi\lambda)}{\lambda m}$$
$$v = \left[\frac{2(hc - \lambda\phi)}{m\lambda}\right]^{1/2}$$

Question113

The graph of kinetic energy against the frequency v of incident light is as shown in the figure. The slope of the graph and intercept on X-axis respectively are

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Options:

A. maximum KE threshold frequency

B. Planck's constant, threshold frequency

C. Planck's constant, work function

D. work function, maximum KE

Answer: B

Solution:

For photoelectric effect,

$(KE)_{max} = h\nu - \phi_0$

where, ϕ_0 is the work function of metal.

On comparing the Eq. (i) with straight line equation $y = mx + c$, we get

Slope, $m = h$ and intercept on y, $c = -\phi_0$ and $\phi_0 = h v_0$

where, v_0 is threshold frequency.

So, for the graph of kinetic energy (KE) against the frequency (v).

Slope = Planck's constant

and intercept on X-axis = threshold frequency

Question114

The maximum velocity of the photoelectron emitted by the metal surface is v. Charge and mass of the photoelectron is denoted by e and m, respectively. The stopping potential in volt is

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Options:

A. $\dfrac{v^2}{2\left(\frac{e}{m}\right)}$

B. $\dfrac{v^2}{\left(\frac{m}{e}\right)}$

C. $\dfrac{v^2}{2\left(\frac{m}{e}\right)}$

D. $\dfrac{v^2}{\left(\frac{e}{m}\right)}$

Answer: A

Solution:

The stopping potential, denoted as V_s, is the potential difference required to stop the fastest photoelectrons emitted from a metal surface. It is directly associated with the maximum kinetic energy (KE) these photoelectrons have when emitted. The relationship between kinetic energy and stopping potential is given by the equation:

$KE = eV_s$

Where:

- KE is the maximum kinetic energy of the photoelectron.
- e is the charge of the electron (approximately 1.6×10^{-19} Coulombs).
- V_s is the stopping potential.

The maximum kinetic energy of the photoelectron can also be written in terms of its mass m and its maximum velocity v as follows:

$KE = \frac{1}{2}mv^2$

Combining the two equations gives:

$eV_s = \frac{1}{2}mv^2$

To find the stopping potential V_s, we rearrange the equation to solve for V_s:

$V_s = \frac{\frac{1}{2}mv^2}{e} = \frac{v^2}{2\left(\frac{e}{m}\right)}$

Therefore, the correct option that represents the stopping potential in terms of v, e, and m is:

Option A: $\frac{v^2}{2\left(\frac{e}{m}\right)}$

Question115

Energy of the incident photon on the metal surface is $3W$ and then $5W$, where W is the work function for that metal. The ratio of velocities of emitted photoelectrons is

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Options:

A. 1 : 4

B. 1 : 2

C. $1 : \sqrt{2}$

D. $1 : 1$

Answer: C

Solution:

To find the ratio of velocities of the emitted photoelectrons when the energy of the incident photon is $3W$ and then $5W$, where W is the work function of the metal, we can use the photoelectric equation. The kinetic energy (KE) of the emitted photoelectron can be described by the equation:

$$KE = h\nu - W$$

where $h\nu$ is the energy of the incident photon and W is the work function of the metal.

For two different incident photon energies $3W$ and $5W$, let's denote the kinetic energies of the emitted photoelectrons as KE_1 and KE_2, respectively:

$$KE_1 = 3W - W = 2W$$

$$KE_2 = 5W - W = 4W$$

The kinetic energy is also given by the equation $KE = \frac{1}{2}mv^2$, where m is the mass of the photoelectron and v is its velocity. Thus, for the two cases above, we have:

$$\frac{1}{2}mv_1^2 = 2W$$

$$\frac{1}{2}mv_2^2 = 4W$$

Dividing the second equation by the first gives:

$$\frac{\frac{1}{2}mv_2^2}{\frac{1}{2}mv_1^2} = \frac{4W}{2W}$$

Simplifying this, we get:

$$\frac{v_2^2}{v_1^2} = 2$$

Taking the square root of both sides to find the ratio of the velocities $v_2 : v_1$, we find:

$$\frac{v_2}{v_1} = \sqrt{2}$$

Therefore, the correct answer is $1 : \sqrt{2}$, which corresponds to Option C.

Question116

The stopping potential of the photoelectrons, from a photo cell is

Options:

A. directly proportional to intensity of incident light

B. directly proportional to frequency of incident light

C. inversely proportional to frequency of incident light

D. Inversely proportional to intensity of incident light

Answer: B

Solution:

The stopping potential of photoelectrons is potential needed to stop the electrons from reaching the collector depends only on the frequency of incident radiation. It is directly proportional to it.

This is because, more the frequency of incident light, more will be the energy of the photons incident photons. $(E = h\nu)$Thus, more will be the energy (kinetic) acquired the electrons.More the kinetic energy of emitted electrons, higher is the potential needed to stop them (stopping potential).

Question117

When certain metal surface is illuminated with a light of wavelength λ, the stopping potential is V, When the same surface is illuminated by light of wavelength 2λ, the stopping potential is $\left(\frac{V}{3}\right)$. The threshold wavelength for the surface is

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Options:

A. $\frac{8\lambda}{3}$

B. $\frac{4\lambda}{3}$

C. 4λ

D. 6λ

Answer: C

Solution:

Given for a metal, wavelength of light used $= \lambda$

Stopping potential $= V$

If λ_0 be the threshold wavelength, then maximum kinetic energy of emitted electrons

$K_{\max} = hc \left(\frac{1}{\lambda} - \frac{1}{\lambda_0} \right)$ .... (i)

Again, wavelength of used light

$\lambda' = 2\lambda$

Stopping potential, $V' = \frac{V}{3}$

then $K_{\max} = hc \left(\frac{1}{\lambda'} - \frac{1}{\lambda_0} \right)$

$\Rightarrow \quad eV' = hc \left(\frac{1}{2\lambda} - \frac{1}{\lambda_0} \right)$

$\Rightarrow \quad \frac{eV}{3} = hc \left(\frac{1}{2\lambda} - \frac{1}{\lambda_0} \right)$ .... (ii)

From Eqs. (i) and (ii), we have

$$\frac{eV}{\frac{eV}{3}} = \frac{hc \left(\frac{1}{\lambda} - \frac{1}{\lambda_0} \right)}{hc \left(\frac{1}{2\lambda} - \frac{1}{\lambda_0} \right)}$$

$$3 \left(\frac{1}{2\lambda} - \frac{1}{\lambda_0} \right) = \frac{1}{\lambda} - \frac{1}{\lambda_0}$$

$$\Rightarrow \lambda_0 = 4\lambda$$

So, threshold wavelength is 4 times of wavelengths of light.

Question118

A metal surface is illuminated by light of given intensity and frequency to cause photoemission. If the intensity of illumination is reduced to one fourth of its original value then the maximum KE of the emitted photoelectrons would be

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Options:

A. twice the original value

B. four times the original value

C. one fourth of the original value

D. unchanged

Answer: D

Solution:

The maximum kinetic energy of photoelectrons is given by $\text{KE}_{max} = h(\nu - \nu_0)$ .... (i)

where, h = Planck's constant,

ν = frequency of radiation

and ν_0 = threshold frequency.

It can be seen from Eq. (i), that the maximum KE of emitted photoelectron is proportional to the frequency of radiation and is independent of the intensity of radiation, so it remains unchanged.'

Question119

When photons of energy $h\nu$ fall on a metal plate of work function ' W_0 ', photoelectrons of maximum kinetic energy ' K ' are ejected. If the frequency of the radiation is doubled, the maximum kinetic energy of the ejected photoelectrons will be

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Options:

A. $K + W_0$

B. $K + hv$

C. K

D. 2K

Answer: B

Solution:

Given, energy of photon $= h\nu$, work function $= W_0$ and maximum kinetic energy $= K$

So, from the Einstein's photoelectric equation,

$E = K + W_0 \Rightarrow hv = K + W_0$
$\Rightarrow \quad K = hv - W_0 \quad$ ... (i)

If frequency of the radiation is doubled, then Einstein's photoelectric equation changed as

$K' = h(2v) - W_0 \quad$ ... (ii)

By substracting the Eq. (i) from (ii), we get

$K' - K = h(2v) - hv - W_0 + W_0$
$\Rightarrow \quad K' = K + hv$

So, option (b) is correct.

Question120

The maximum velocity of the photoelectron emitted by the metal surface is ' v '. Charge and mass of the photoelectron is denoted by ' e ' and ' m ' respectively. The stopping potential in volt is

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Options:

A. $\dfrac{v^2}{2\left(\frac{m}{e}\right)}$

B. $\dfrac{v^2}{2\left(\frac{e}{m}\right)}$

C. $\dfrac{v^2}{\left(\dfrac{e}{m}\right)}$

D. $\dfrac{v^2}{\left(\dfrac{m}{e}\right)}$

Answer: B

Solution:

Given, maximum velocity of a photoelectron $= v$

charge of photoelectron $= e$

and mass of photoelectron $= m$.

Let, the stopping potential of the photoelectron $= V$,

Then, the maximum kinetic energy

Then, the maximum kinetic energy

$$KE_{\max} = eV \Rightarrow \frac{1}{2}mv^2 = eV \left(\because KE = \frac{1}{2}mv^2 \right)$$

$$\Rightarrow \quad V = \frac{v^2 m}{2e} \text{ or } V = \frac{v^2}{2\left(\frac{e}{m}\right)}$$